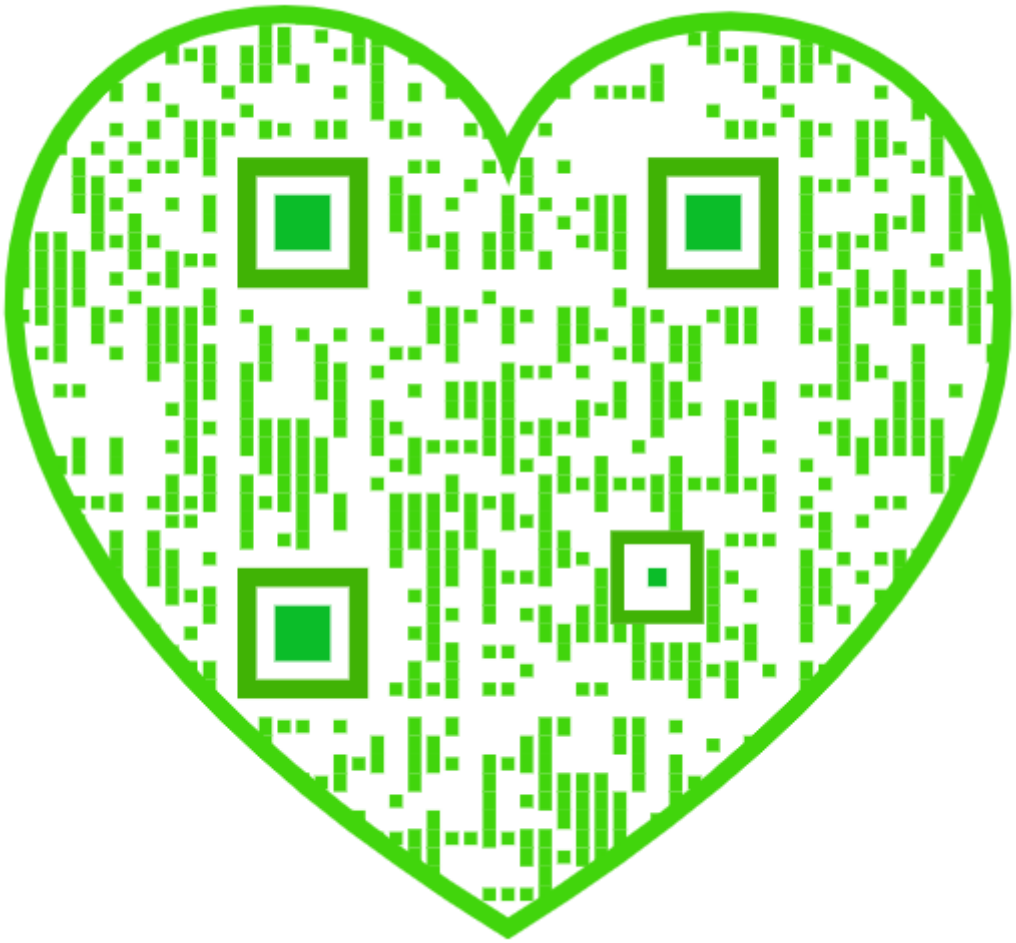
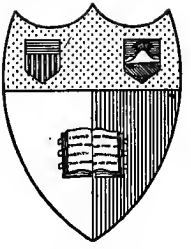
# RECREATIONS IN BOTANY





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# RECREATIONS IN BOTANY

BY

CAROLINE A. CREEVEY

ILLUSTRATED

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TO

MY FRIEND

MARGARET E. SANGSTER

THIS VOLUME

Is Lovingly Inscribed

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# GLOSSARY OF BOTANICAL TERMS

*Achene, or Akene.*—A small, dry, indehiscent, one-seeded fruit.

*Adventitious.*—Accidental. Applied to buds springing from unusual places.

*Anemophilous.*—Wind-loving. Applied to flowers fertilized by the wind, as pines.

*Anther.*—The part of the stamen which contains the pollen, usually consisting of two cells, which open, when the pollen is ripe, by a slit.

*Apetalous.*—Without petals, as the anemone.

*Axil.*—The upper angle at the junction of stem and branch.

*Axis.*—The stem; the part around which other organs are attached.

*Bracts.*—The small leaves at the base of or upon the flower-stem.

*Calyx.*—The outer flower-leaves, usually green.

*Capsule.*—The dry, dehiscent fruit of a compound pistil, as in poppy.

*Caudicle.*—The stalk of the pollen-mass in orchids.

*Caulicle.*—A little stem. The radicle of seeds.

*Cellulose.*—The substance of which cell-walls is composed.

*Chlorophyl* (written also with two l's).—Leaf-green. A soft granular substance found in green parts of a plant exposed to light, whose office is to convert crude sap into vegetable material.

*Cleistogamous.*—Closed fertilization. Applied to inconspicuous blossoms which are self-fertilized before the bud opens, as in stemless violets. Such plants bear other, more conspicuous blossoms, which are often unfruitful.

*Circinate.*—Rolled from the tip downward, as in the young fern fronds.

*Column.*—The body formed by the union of stamens and pistils in orchids.

*Corolla.*—The flower-leaves standing next within and above the calyx.

*Corymb.*—A cluster of flowers, flat or convex at the top, blossoming first at the circumference, last at the centre.

*Dehiscent.*—Splitting open of capsules into regular valves for the discharge of seeds. Dehiscent fruits contain more than one seed.

*Dicotyledonous.*—Having two cotyledons or seed-leaves.

*Dimorphous.*—Two-formed. Applied to plants like the partridge-berry, in which high anthers and low stigmas are found in one flower, and high stigmas and low anthers in another. The visiting insect carries pollen from high or low anthers in one flower to corresponding stigmas in others.

*Disk.*—The central part of composites, as distinguished from ray-flowers.

*Drupe.*—A stone-fruit. Cherries, plums, etc., are drupes.

*Endogenous.*—Increasing by inside growth and elongation of the apex. Palms, grasses, lilies, etc., are examples. The wood is made up of separate threads scattered irregularly through the whole of the stem.

*Entomophilous.*—Insect-loving. Applied to plants which are fertilized by visits of insects.

*Epiphytes.*—Air-plants. Plants fastened upon other plants, but nourished by the air only.

*Exogenous.*—Increasing by growth in rings around a central pith. The wood-bundles are wedge-shaped, radiating from the centre. The whole is covered by bark. Maples, and most of our trees, are exogens.

*Filament.*—The stamen-stalk, bearing the anther.

*Floret.*—Diminutive of flower. Applied to the small flowers of composites.

*Fronds.*—The leaves of ferns, algæ, liverworts, etc.

*Glabrous.*—Smooth; that is, without hairs or bristles.

*Gymnosperms.*—Naked-seeded, cone-bearing plants, as pines and hemlocks.

*Haustoria.*—Sucker-like rootlets of dodder and poison-ivy.

*Indusium.*—The scale-like covering of the fruit of ferns.

*Labellum.*—Lip. A name given to the single large petal of orchids.

*Metastasis.*—The process by which plants convert one form of vegetable matter into another.

*Monocotyledonous.*—Embryo containing one cotyledon. Such plants are endogenous, and the leaves are parallel-veined.

*Monopetalous.*—Corolla united into one piece, like campanula. Gamopetalous is a more modern term for the bell-corolla.

*Node.*—Joint. The part of the stem bearing a leaf or branch.

*Ovary.*—The part of the pistil bearing ovules.

*Ovules.*—Unfertilized seeds.

*Palmate* (leaves) are borne on the tip of a common stalk—*e.g.*, horse-chestnut.

*Panicle.*—A compound flower cluster, irregularly branching—grasses, lilies-of-the-valley are examples.

*Pappus.*—The calyx of composites—thistle- and dandelion-down.

*Parenchyma.*—The soft cellular tissue of plants.

*Pedicel.*—The stalk of each individual flower of a cluster of flowers.

*Peduncle.*—The naked stalk of a flower. The stalk on which a cluster of flowers is borne is the common peduncle.

*Perfect.*—As applied to flowers, having both stamens and pistils.

*Perianth.*—The floral envelopes taken collectively.

*Petal.*—A division of the corolla.

*Petiole.*—The foot-stalk of a leaf.

*Pinnate* (leaves) are compound leaves, in which the leaflets are arranged on a common stalk, which answers to the midrib of a simple leaf. Locust and ash are examples.

*Placenta.*—The seed-bearing part of the ovary.

*Plumule.*—The bud just above the cotyledons of a germinating plant.

*Pollinia.*—Pollen-masses of orchids.
*Polypetalous.*—Distinct petals. Geraniums are polypetalous.
*Prothallus.*—The first product of a fern-spore.
*Protonema* (Pl. protonemata).—Answering, in mosses, to the prothallus of ferns.
*Protoplasm.*—The living contents of cells.
*Pyxis.*—A pod opening by a lid.

*Raceme.*—"A flower-cluster, with one-flowered pedicels arranged along the sides of a general peduncle."—*Gray.*
*Receptacle.*—The tip of the flower-stalk, upon which the floral parts are regularly arranged.
*Rhizome.*—A root-stalk; a creeping stem or branch.

*Sepals.*—Divisions of the calyx.
*Sessile.*—Sitting; of a leaf or flower, destitute of stalk.
*Silique.*—Capsule of the mustard family.
*Sori.*—The fruit-dots of ferns.
*Spadix.*—A fleshy spike or head of flowers. Indian turnip and calla are examples.
*Sporangia.*—Spore-cases of ferns.
*Stigma.*—The loose, spongy part of the pistil, which receives the pollen.
*Stipe.*—Stalk of ferns and mushrooms.
*Stipules.*—The appendages which grow on opposite sides of a leaf. Sometimes united, they sheathe the stem, as in the buckwheat family.
*Style.*—The stalk of the pistil (when it has any) bearing the stigma.
*Symmetrical.*—When the number of all the parts of a flower is similar (*e. g.*, five sepals, five petals, five or ten stamens, five pistils, or five divisions of a simple pistil) the flower is symmetrical.

*Thallus.*—Leaf-like. A cellular, thread-like expansion, erect, spherical, or of any form, taking the place of stem and leaves in the lowest orders of plants, and giving the name thallophytes, or thallogens to such plants.

# RECREATIONS IN BOTANY

## I

## INTRODUCTORY

Botany an Out-door Sport — Pleasure of Knowing the Names of Plants—Dangerous and Criminal Classes—Poison Ivy—Poison Sumac — *Drosera Rotundifolia* — Bladderworts — Parts of a Flower

An old game, called golfing, has been revived in England, and is attracting considerable attention. It consists in knocking a ball into holes over a two or three-mile course. Obstructions, such as fences, ditches, and even ponds, lie in the way, and the successful "golfist" is the one who sends his ball into all of the holes with the fewest number of hits. Ladies play successfully, and acquire muscle thereby and the habit of rapid walking.

It is but one of the numerous devices, with croquet and lawn-tennis, for keeping young people out-of-doors and making them athletic.

The pursuit of botany ought to be ranked as an out-door sport. While not possessing the attraction of a game in which skill wins, it is yet more nearly allied

to hunting and fishing than to piano-playing or any indoor study. It furnishes an impulse to and interest in many a tramp by forest and stream. It has this in its favor, too, that when one has made his "bag," or "string," no timid bird or helpless fish has been sacrificed, and no pain has been inflicted to give the botanist a holiday. His delight when he comes upon a rare find, a beautiful fern or orchid, is fully equal to that of the mad rider who wins "the brush," or the patient angler who takes the biggest fish.

I shall never forget the beautiful sight which rewarded a desperate climb up steep, pathless rocks through a tangle of bushes, to where a broad, level spot was covered with the prickly-pear cactus in full bloom. There they lay, the great yellow beauties, drinking in the sunlight—a scene I had supposed possible only on the Western prairies.

It surely is no mean ambition to wish to know the names of things we see. An intelligent writer on politico-economic subjects, who is fond of riding, said recently, "It is a great drawback on my pleasure in the parks and in the country that I don't know the plants and flowers which I see."

There are two ways of finding out such things. One is to ask some one who knows (not always easy), and the other is to analyze the flower, and "trace" it in the Manual one's self. The first method may be likened to the "pony" style of translating a foreign language.

Independent investigation always wins its own reward; never more so than in the study of plants. Be-

sides the joy of success, one who can always answer the question, "What is it?" becomes quite an oracle among his friends, and gets credit for having taken more trouble than is actually the case. For (and this is one of the points I wish to emphasize) botany is the easiest of all the sciences, and can be engaged in without a teacher.

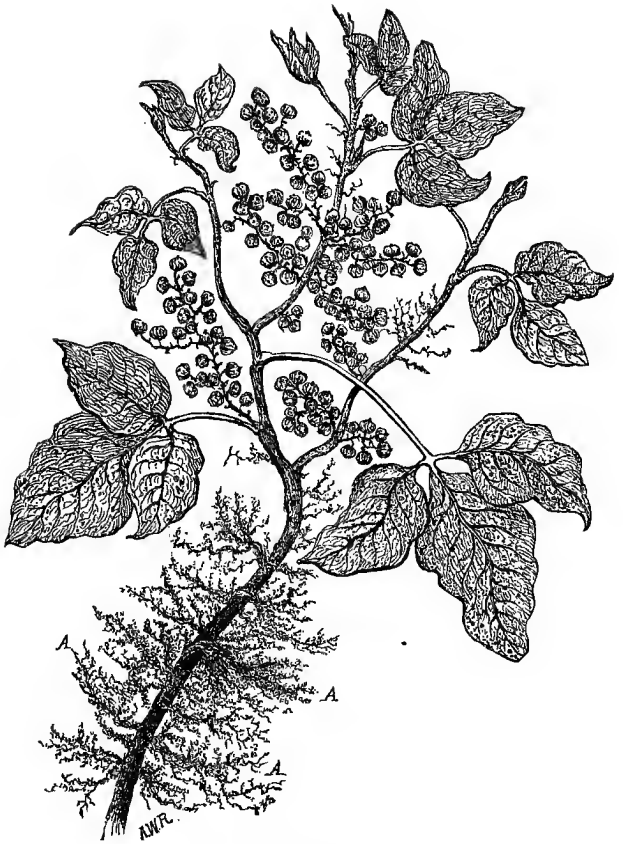
Is it not a sin and a shame that country people, who live the year round among the lavishments of nature, are as a rule so indifferent to them? The farmer's wife knows that catnip is good for tea; but there is a curious little pimpernel growing in her garden which shuts its petals on the approach of bad weather, and which she has never seen. The farmer knows the wild-carrot for a useless weed, the corn-flower for a yellow daisy, but he does not know the trees of the road-side, much less the shrubs. One, a practical, shrewd man, told me that the dwarf sumac (*Rhus copallina*) was the poison-sumac. For more than seventy years he had lived in northern New Jersey, and been afraid to touch this innocent bush. Two of the six species of sumac are to be ranked among the dangerous and criminal classes of plants, and should be studied in order to be avoided. Like other evils, they are seductive, especially in their gorgeous autumn dress; but the cloven hoof can be seen after reference to the Manual. The poison-dogwood, or elder, or sumac, as it is variously called, is a tall shrub growing in swamps. Its bark is grayish; its leaf-stems are red.

The poison-ivy, a vine with three leaflets (often mis-

taken for the Virginia creeper, which has five leaflets), frequents road-sides, and clusters about fence-posts and trunks of trees. Many farmers don't "bother" with it,

POISON - SUMAC

but let it grow, a constant menace to barefooted boys and ignorant pedestrians. The blossoms of these venomous species are axillary; that is, grow in the angle




POISON IVY

formed by the stem and the branch. The berries are white. If you find a sumac with *terminal flowers* and *red berries*, it is as safe to handle as a buttercup.

The lover of curious things will be amply rewarded by a study of flowers. Under the microscope even common weeds become interesting, and a discovery of the habits of some plants is like a peep into Wonderland.

Pluck the small round-leaved sundew (*Drosera rotundifolia*). The hairy and sticky leaves grow in a tuft at the base. Under the microscope the hairs are transformed into numberless bristles tipped with purple jewels. Small, sorry insects are caught among these ruby glands, which close over them like tentacles, and entangle them, and imprison them with purple threads. Inside the glands an extraordinary activity is aroused. A

DROSERA ROTUNDIFOLIA

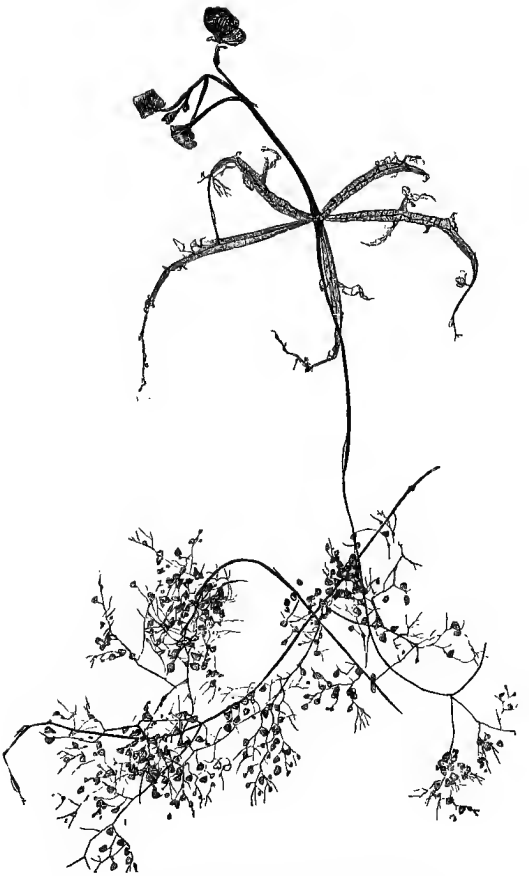
reddish fluid, akin to the gastric juice of our stomachs, is digesting and assimilating the insect food. This innocent-looking plant, with its modest flower responding only to sunshine, is carnivorous, and thrives upon animal food.

Hardly less wonderful are the bladderworts which grow in the neighboring pond. The plants float upon the surface of the water by means of countless little bags full of air, joined to the seaweed-like leaves. The ripe seed falls to the bottom, takes root, and grows there in soil. When the flowering time arrives, the bladders fill with air (who can tell how?), buoy the plant upwards, dragging it, roots and all, to the surface, in order that the flower may breathe air and sunshine.

While it is not claimed that botany, like Greek or mathematics, can produce mental brawn, yet it certainly does cultivate close observation, prolonged attention to minutiæ, a habit of comparison and deductive reasoning—all mental qualities worth possessing.

There are a few fundamental facts which should be generally known. The end of a plant's existence is not to make pretty flowers, but to reproduce itself. Its stamens and pistils serving this purpose, every effort of the plant is put forth to perfect them and bring them together; and the flower-leaves are only covers and protectors of these delicate and important organs. Sometimes, as in the lizard's-tail, the flower-leaves are wanting, and the flowers are composed only of stamens and pistils.

A single pistil occupies the place of honor, the centre of the flower. Pea and bean pods are examples of



FLOWERING STEM OF UTRICULARIA INFLATA

simple pistils. The buttercup and anemone show numerous pistils crowded upon the end of the flower-stalk.

The parts of a pistil are the ovary, style, and stigma. The ovary, at the base, holds the seeds in one or more separate cells. The style, a threadlike hollow tube, connects the ovary with the stigma, which is a glutinous, sponge-like surface, adapted to the reception and absorption of pollen-grains. The style is sometimes wanting. When the ovary is ripened it is called a fruit, and not only are the apple and plum such fruits, but the feathery-tailed achenia of the lovely virgin's-bower, the mustard pod, and the downy seed of the dandelion are, to the botanist, fruits. Dehiscent fruits split open and scatter their seeds without help. Fleshy fruits, as apples, and dry fruits, as nuts, must either decay or be opened by animals eating them. Raspberries and blackberries are clusters of distinct fruits. The strawberry is a fleshy receptacle with the fruits lying outside.

Stamens surround the pistil when found in the same flower. Often, however, they grow in separate flowers, even upon different plants. Every one knows the full and graceful staminate flowers of the early meadow-rue, and the compact, hard, pistillate flowers, growing perhaps several feet away. Insects and winds, in such cases, act as pollen-carriers.

A stamen has a filament, or stem, and anther, containing the pollen-grains in one or two cells. A water-lily presents a beautiful study of petals passing into stamens. It may have suggested the theory that stamens and pistils are but changed flower-leaves.

In orchids there is but one stamen, with one two-celled anther. The stigma divides the cells, and is closely fastened to them. Orchids are more common than is supposed, and can be found in fields and old orchards as well as in deep woods. There is no more stately flower than the white-fringed orchis, or more exquisitely beautiful than the purple arethusa, or more curious than the stemless lady's-slipper. The family is found in all its rich variety only in the tropics, where they are often fragrant. In Java alone there are three hundred species.

The calyx and corolla stand under and outside of the stamens and pistils. Their separate divisions are sepals and petals. The calyx may cling to the ovary, and grow with it to final fruit. In the huckleberry the top of the edible calyx may be seen in five little points around the centre of the berry. In the apple and pear it is the dry, chip-like part terminating the core.

Apetalous flowers show the corolla wanting. The calyx then expands into petal-like leaves. Such sepals, taking the place of petals, are the six spreading leaves of a lily. Bracts, green or colored, are often crowded under the flower. The monarda (wild-bergamot) has beautiful purplish and yellowish bracts covered with soft velvety bloom. The scarlet painted-cup has both bracts and upper leaves of a bright red color.

With the knowledge of very few botanical terms, it is possible to begin practical work in the study and analysis of flowers. How this may be done will be the subject of the next chapter.

## II

## THE BOTANIST'S TOOLS AND METHODS

Botany-box — A Perfect Specimen — How to Analyze a Flower — Under- and Over-development of Species—Variations of Color—Herbarium

PLUCKED flowers will keep fresh for several days, if shut up in a dark, moist place. Such a place is furnished by the botany-box, made of tin, long and narrow, japanned within to keep it from rusting. Its cost is about two dollars. The lid is large, nearly the whole of one flat side, and closes tightly. A strap attached to the box may be worn over the shoulder, or it may be carried by a handle. It should accompany every walk and ride, and flowers should be placed in it as soon as gathered. If a sprinkle be added from a neighboring brook, they will keep fresh for three or four days, and can be examined at leisure. A beginner cannot take too great pains to keep his specimens in good condition, as he will understand after he has tried to analyze a dried or wilted flower. In procuring specimens, a jack-knife or small trowel is necessary for digging up roots.

A perfect specimen has roots, leaves, blossoms, and fruit. Fruit, more or less advanced, can generally be found by searching. In any event, the botanist will gather several specimens of the same kind, for he may fail to find the type perfectly developed in one. At

home now, pleasantly wearied with our morning's walk, we arrange a comfortable seat under the trees, with our botany-box and Gray's Manual within reach. A lead-pencil, a sharp penknife, and, most important of all, a pocket-microscope, complete our outfit. Nobody will call, since nobody knows us in our country retreat, and we look forward to an afternoon of unalloyed pleasure. Before exploring the cool, moist depths of the botany-box, a beginner will best learn how to go to work, by taking something he knows, and tracing it backward.

The yellow wood-sorrel growing at your feet, whose sour leaves when eaten used to please your childish taste, will do. It is easy, because perfect and symmetrical. Composites such as the daisies and dandelions, wild-carrots, and other members of the parsley family, are not easy. Leave them for later study.

On page 109 of the Manual is an accurate description of the wood-sorrel. The numerical plan of the flower is five. There are five sepals, petals, styles, and twice five stamens. Cut across the five-lobed pod, and see that it has five cells. The leaves, too, are described. They are alternate, with obcordate leaflets, which "close and droop at nightfall." They also close and droop soon after being picked, as you learn by looking at the one in your hand. Look out the meaning of obcordate and other strange terms in the glossary joined to the Manual, and refer to the cuts and paragraphs in the "lessons" which illustrate them. In this way the technical terms will be mastered almost without effort. Turning now to the polypetalous divison of flowering

plants, we shall easily trace the family, *Geranaceæ*, to which the sorrel belongs. A few such trials cannot fail to teach us some fundamental facts, and prepare us for attempting to analyze unknown flowers.

We come across two long and hard words at the very outset, which should be understood, once for all. The seed-leaves are called cotyledons, and all plants which start from the seed with two such leaves are called dicotyledonous. They are by far the greater number, and in all of them the stem-wood grows in circles, one each year outside of another, during the plant's life, the centre being pith (or hollow in the case of some annuals), the whole covered with bark. Such growth is called exogenous. The stem of an iris, or stalk of Indian-corn, has no such growth. The wood runs up and down in threads or bundles of threads, with cellular tissue between. This *endogenous* manner of growth belongs to plants which start from the seed with one cotyledon, giving the name to the second great class, *mono*cotyledonous. Our sorrel belongs to the first class, and is *poly*petalous, because all the petals are present and divided. If, as in the primrose, the petals are more or less united, the plant belongs to the *mono*petalous division; and it is *a*petalous if, as in the wood-anemone, they are wanting altogether.

### HOW TO STUDY PLANTS

Make constant use of the microscope. A pocket-lens, magnifying about fifteen times, is the one most used,

and can be bought for one dollar and a half. Nothing is more ruinous to the eyesight than the attempt to count stamens and ovary cells with the unaided eyes.

Consider first the root. Is it bulbous, a root-stalk, or a cluster of rootlets?

Next, the leaves. Are they alternate, opposite, or whorled? Cut and divided, or entire? What is their outline and shape?

Hold them up to the light, and scan them for light or dark dots, such as you will find in the Saint-John's-worts. Next look at a cross-section of a bud. Do the leaves just touch one another on their edges, or do they overlap, like shingles?

Take a flower and gently remove the sepals, observing whether they come off entire or are joined to the ovary. Remove the petals one by one, and see if the stamens are attached. If the stamens are more than twice the number of the petals, do not count them. They are "numerous." Cut an ovary, the largest you have, across, and with a gentle pressure of thumb and finger squeeze out the seeds. You can the better count the empty cells, and see how the seeds are joined to the placentæ. Wipe the knife blade, to prevent rusting. Study the flower and plant until you know everything that anybody knows about it before you open the Manual. You will then have gained much more than the name, and the data for determining that.

One summer's study will make the student so familiar with the characteristics of the great families that he

will know a milk-weed, or an evening-primrose, or a mint, or heath, as soon as he sees it.

When the plant has been traced, draw lines around the description in the botany, and write in the margin when and where the plant was found. Some walk or ride or picnic is thus, by pleasant association, made historic.

Do not be puzzled or discouraged if the description in the botany and your plant differ in some unimportant particular. Dry soil may produce an under-, rich soil an over-development of the species. I have found the Joe-Pye-weed (*Eupatorium purpureum*) with opposite leaves, differing from the usual manner of growth, which is, as the botany says, two to six in a whorl.

Mr. Gray has been charged with color blindness, because he does not accurately distinguish shades of red. Crimson tints with him are "purplish." He says of the viper's-bugloss (*Echium vulgare*) that the corolla is "reddish-purple, changing to brilliant blue." In fact, the younger flower is blue, changing with age to red. Such inaccuracies should not disturb the student. He learns, on the whole, to admire the marvellous thoroughness with which Mr. Gray's work has been done, and to regard the great botanist with the affection one gives to a personal friend.

The herbarium is a necessity if one would become a good botanist. We forget so easily, that the results of one summer will be lost before the next, unless we can sometimes refer to our "collection."

Newspapers are good enough for pressing. Procure

several, and tear them into sheets of uniform size. If you take the flower right from the box, its leaves will lie flat, and will almost arrange themselves. Place several thicknesses of newspaper between the plants; cover under and over with flat boards about two feet long, and press under a trunk or equally heavy weight. A separate press for small and delicate flowers can be made of old magazines under a pile of books. These must be looked at oftener than those in the big press, but every day until the juices of the plants are dried, all the specimens should be transferred to clean and dry newspapers. The plants which retain their color best are those which are thoroughly dried in the shortest time. They may take twenty-four hours, and if "fleshy," a week, or even more. This may seem a crude way of drying specimens, but for a traveller, living in trunks, away from home, it is practicable, and therefore commendable.

Let the pages for the herbarium be of uniform size and quality. At any printing-office white or Manila paper, cut into half-sheets, can be obtained. The approved size is $16\frac{3}{8}$ inches by $11\frac{1}{2}$. Disregarding the fractions, 17 by 12 is a very convenient size. For strictly scientific purposes, one specimen only is allowable on each page. But for purposes of comparison, it is useful to lay two or even more species upon the same page. Fasten the stem and branches with short narrow gummed strips of paper. When the stem will not lie flat, tie it with a needle and double thread on the underside. Upon the right-hand lower corner write in ink the botanical (genus and species) and common names

of the flower, with the time and place of its gathering, and other bits of information. Especially note the color of the blossom, as it may have changed in drying. Red and yellow flowers retain their color best; white turns brown or black; blue and pink turn white.

Place the species belonging to one genus inside of covers of thick Manila paper. These "genus covers" should be labelled and grouped again in a portfolio or box under "Families." The private collector will then doubtless find his house too small. It certainly will not easily offer a closet or case large enough and suitable for his botanical collection. To the enthusiast, however, everything is possible.

All this may seem like taking a good deal of trouble, and it is; but it pays. It is the most fascinating kind of work. It possesses over needlework the distinct advantage of taking the student out-of-doors for many hours at a time. The collector cannot fail to exhibit the results of his summer's work with a pardonable pride. And admiring friends will say, perhaps, as one of mine did:

"Why, how busy you must have been! And how like a pretty picture those ferns are, held up to the light and looked at from the back!"

## III

## FERTILIZATION OF PLANTS

Usefulness of Insects — Self-fertilization of Plants the Exception to the Rule — Wind-lovers — Insect-lovers — Devices for Attracting Insects — Examples of Flowers which seek Cross-fertilization

No one ever questioned the wisdom which covers the earth with flowers. Without them our fields and forests would be as desolate as are the sides of the Jungfrau.

But we are accustomed to regard insects with no such fondness. They sting and bite us, make housekeeping a burden, destroy the garden plants, come in vast swarms over the prairies, as in the days of Egypt's plagues, till we think of them only with a fierce desire to destroy every insect that ever lived.

Fortunately they have a usefulness all their own, and none the less real because unconsciously exercised. Think, if there were no insects, how the birds would mourn for their toothsome grubs and fat green caterpillars. And the flowers would produce almost no fruit, and in a little time the vegetable world, all that springs from seed, would cease to exist.

Geologists know that dicotyledonous plants did not occur in large numbers till nectar-seeking insects were evolved. For the curious fact is that the greater num-

ber of flowers are fertilized by the aid of insects, and do not wish to fertilize themselves—in fact, take great pains to prevent a union between their own organs.

We have seen that the object of a plant's existence, from the first appearance of the plumule to the ripening of the fruit, is to reproduce itself. But when the pollen is ready, and the stigma is receptive, the flower itself can do no more. Outside agents are invoked, and wonderful are the adaptations of the flower for this purpose—that of securing foreign interference.

Birds are such agents, especially humming-birds, but the most important are winds and insects.

Let us recall a few facts about pollen-grains and their office. They are minute powdery grains of yellow dust, and are carried about separately or in masses.

POLLEN-GRAINS

The anther-cells open variously, by slits or holes, setting free the pollen when ripe. The filament is then firm and elastic. After the pollen is liberated, the stamen becomes limp, and soon withers. A pollen-grain falling upon the glutinous, moist, spongy surface of the stigma bursts its outer coat, its inner, sensitive coat contracting and elongating into a delicate tube, which pushes down the hollow style, borrowing nourishment as it goes. When it reaches the ovule (the unfertilized seed), it enters, penetrates the embryo sac, is absorbed into it; and now a globule of living matter is formed. Here science stops. The Creator's finger seems to touch this atom, and it becomes energized, a miniature of the full-grown plant, perhaps the beginning of a spreading forest tree. How clumsy man's most delicate mechanisms seem when we stand in the presence of the mystery of vegetable life!

It is essential that the pollen and stigma of like species be brought together in order to produce fruit. Hybrids are formed by the crossing of different though nearly allied species, and are not reproductive.

Self-fertilization takes place sometimes in the closed bud, and receives the name cleistogamous (hidden fertilization). The Venus's-looking-glass (*Specularia perfoliata*), the jewelweed (*Impatiens*), and wood-violets are cleistogamous. Not every one knows that violets produce two kinds of blossoms—those in spring, which we all know and love, and others without petals, in summer, which are fertilized in the unopened bud. You must pull aside the leaves to find the summer blossoms

and their pods in autumn. These concealed blossoms are much more fruitful than those of spring.

There is a delicate little plant with an ugly name, very common in woods, climbing over everything, producing small pea-like blossoms. It is the hog-peanut (*Amphicarpæa monoica*). Near the base, almost under the earth, are apetalous blossoms producing pods which ripen one large seed.

There is great economy in the pollen of cleistogamous flowers. The jewelweed has about two hundred and fifty grains of pollen in a single flower; the stemless violet one hundred. In flowers fertilized by a foreign agent, since so much pollen is to be wasted, nature has granted a lavish supply. In a single flower of peony there have been found three and a half millions of pollen-grains.

Sprengel (1750–1816) discovered that flowers containing both stamens and pistils do not necessarily fertilize themselves. The theory obtained no notice, except for ridicule, until that great naturalist, Charles Darwin, declared that Sprengel's views fell short of the actual truth, that "nature abhors self-fertilization," and takes every means to prevent it, and that seed produced from cross-fertilization (that is, pollen of one flower united to stigma of another) will give rise to plants often twice as large and strong as plants grown from self-fertilized seed.

Of Professor Darwin it was said that "he was able by gentle persuasion to penetrate that reserve of nature which baffles smaller men." The "gentle persuasion"

was hard, systematic work born of wonderful enthusiasm. He rose early, to watch the awakening of the animal and vegetable world. His book on orchids, a fascinating book for any one to read (even, as he says himself, "a woman may understand it!"), was the product of eleven years of minute, careful experiment. With delicate instruments he introduced pollen of plants to stigmas. Each seed had an individuality to him. His pots were protected by glass covers from any possible contact with other plants. All his shelves and greenhouses were filled with the plants which he was watching. His discoveries kept him from sleeping, they were so wonderful. And yet, like all really scientific men, he was as modest as a child, and after the publication of a paper or book, would await with anxiety the verdict of such friends as our own Dr. Asa Gray, leaping into an ecstasy of delight when the theory was received and approved.

Plants which are fertilized by winds are termed wind-lovers (anemophilous). The wind as a bearer of pollen must not be confounded with the wind as a disseminator. Many plants, as the dandelion and milkweed, are fertilized by insects, but their feathery-tailed seeds are blown in every direction by the wind. Grasses, sedges, plantains, catkin-bearing trees (except willows), and cone-bearing trees are wind-lovers. Such flowers are dull in color, without odor or nectar. The pollen is light, dry, and abundant. It is when the pine forests are filled with flying pollen that they are especially prized as sanitaria.

The insect-lovers (entomophilous) must attract insects; therefore are showy, fragrant, nectariferous. It is not for us that the lily hangs out its handsome bells, and the azalea and columbine waft their delicate odors. They hope to lure the honey-bee and butterfly. They seek to detain the pretty-winged moth, with brighter eyes and keener scent than ours, and they offer in exchange for a service so needful, a feast of ambrosia fit for the gods.

The irregularities of flowers like the mints, figworts, pulses, and orchids are now seen to have design. There is one large petal for the insect to stand upon, a tube into which the insect must thrust its proboscis, while its body comes in contact with stamens and pistils. The opening towards the nectar and the standing-place of an irregular flower invariably facilitate the rubbing of the insect's body, or proboscis, or head, against pollen, so that when it leaves that flower it is dusted with yellow grains for the pistil in the next flower which it visits.

A few examples will show the special adaptations of flowers for preventing self-fertilization and securing that of insects; and first, cases in which the anthers and pistils of the same flower mature at different times. Manifestly the design of nature is that these should not be united.

In the chocolate brown flower of scrophularia the stigma is first receptive, and projects over the under lip of the corolla. The stamens are then down deep in the corolla tube, the anthers closed. Later, perhaps the

next day, the stamens have come up and forward, the anther-cells lie open and discharge their pollen. But now the stigma is past its usefulness, it hangs limp and dry. An insect, if it visits this flower, will carry the pollen to an earlier opening flower whose stigma is receptive.

The *Epilobium angustifolium* (one of the fireweeds) and *Sabbatia*, among the gentians, are examples of the stamens maturing before the pistil. While the anthers of *Sabbatia* are discharging pollen, the pistil is bent and twisted to one side. When the anthers have finished their work, then the pistil rises, straightens itself, and throws out branches whose inner surface is in a receptive condition. Pollen must be brought from an earlier opening flower for this tardy pistil. The *Sabbatia gracilis* is a lovely rose-pink flower, growing in profusion along the New Jersey coast.

In some of the Compositæ the anthers close in a tube around the style and deposit pollen-grains upon it while it is low down. It elongates gradually, carrying the pollen with it, but the stigma is still above, out of reach.

The lovely campanula has a similar method. The pollen is discharged in the closed bud upon the backs of the three or five stigmas. When the flower opens, the stamens are withered. The pistil spreads its branches. Its own pollen — so near, and yet so far — lies just beneath, but none of it is destined for itself. The bee will carry this pollen to another flower, and bring to this pistil other pollen which it has caught upon its legs or body.

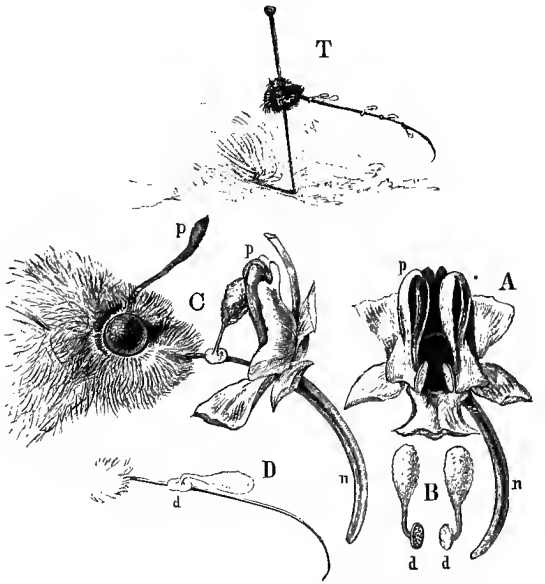
The mountain-laurel hides the heads of the stamens in little pockets (or bosses). An insect alighting jostles the stamens. They spring up; the pollen flies through chinks in the tops of the anthers, and the insect is covered with the yellow grains.

Some flowers, like wistaria, have a fine fringe of hairs just below the stigma, which can have no other purpose than to intercept pollen from their own stamens, and prevent it from lodging there. In all flowers of the pea family the insect's weight depresses the keel (the part of the flower enclosing the stamens and pistil) until the anthers and stigma protrude. They are thus brought against the insect's abdomen.

In orchids and milkweeds the pollen is carried, not in distinct grains, but in masses held to a central stem by elastic threads. The stigma of an orchid is (usually) a broad, glutinous surface. Variously adherent to it are the two cells of a single stamen. The pollen-masses (pollinia) are terminated by a buttonlike gland, which is kept sticky by wonderful processes. When an insect inserts its proboscis into a flower of Habenaria, its two eyes rest upon the sticky glands. When it flies away the viscid disks adhering to each eye are dragged out with the pollen-masses and carried to the next blossom, where they are deposited upon the stigma. Insects are sometimes seen with two or three viscid disks attached to each eye.

Dimorphism is a term applied to plants having two lengths of pistils and stamens. The partridge-vine (*Mitchella repens*) has some flowers with long stamens

and short pistils, and others with short stamens and long pistils. The long pistils must be fertilized by the long stamens to produce good results, and the short




MAGNIFIED VIEWS OF THE PARTS CONCERNED IN THE OPERATION OF EXTRACTING NECTARY FROM AND IN FERTILIZING ORCHID FLOWER BY HAWK-MOTH

A. Opening of flower, showing aperture of nectary and stigma immediately above, with a pollen-pouch on each side. n. Nectary. p. Pouch. B. Pollen-masses removed, showing their position in pouches. d. d. Viscid disks. C. Head of hawk-moth, showing viscid disk clasping toogue, and one fastened to the eye, and being withdrawn from pouch. n. Nectary. p. Pouch. D. Horizontal position immediately assumed by the tiny club. d. Disk. T. Appearance of toogue of moth after exploring several flowers.

pistils by the short stamens. The pollen-grains of the long stamens are larger than those of the short. There are long-styled and short-styled varieties of oxalis. When growing by themselves, they are sterile. When planted together, they produce seed.

The *Lythrum salicaria* is a remarkable trimorphic flower. Each flower contains stamens of two different lengths, with its pistil. In three different flowers will be found short, middle-sized, and long styles and stamens. Each pistil must be fertilized with pollen from stamens of corresponding length.

Professor Darwin once wrote to Dr. Asa Gray : "I am almost stark, staring mad over lythrum. If I can prove what I fully believe, it is a grand case of trimorphism, with three different pollens and three stigmas. I have fertilized above ninety flowers, trying all the eighteen distinct crosses which are possible within the limits of this one species. For the love of Heaven, have a look at some of your species, and if you can get me some seed, do."

## IV

## ORCHIDS

The Taste for Orchids not a Passing Fancy — Earth-growing and Epiphytal Orchids—Difficulty of Collecting, Transporting and Growing Tropical Plants — Characteristics — "Highly Specialized" — Cypripediums and Other Native Orchids — Rare and Beautiful Species Found in Hot-houses

The fascination which orchids possess for us, unlike the tulip craze of a couple of centuries ago, is rational. The tulip at best is a gaudy flower, with no grace of form or perfume. The taste for orchids, which has been growing for fifty years, is not a passing fashion, since the orchids are worthy of admiration. No other flower combines so much that is beautiful and interesting. In color they are deep and pure, delicately shaded and boldly marked. The ever-varying forms of the perianth are curious, sometimes to the verge of grotesque. Many of them exhale powerful odors. Moreover, when considered from a botanist's point of view, in their structure, modes of growth, the renewal of their plant life, and their habitations, this family of plants must stand pre-eminent over every other.

Their introduction into the greenhouses of Europe is not recent. It dates from the beginning of our century. The first real success in their domestication was achieved,

after a long series of failures, by Mr. Cattley, whose name has been given to the large and splendid genus of Cattleya. His method was perfectly simple. It was to imitate the soil, temperature, moisture—all the conditions of growth of the plants in their native country. Soon collectors were sent to the East and West Indies at great expense. Belgium, Switzerland, Germany, Russia, and, last of all, France, imported new and choice specimens, and erected large houses for their reception. To-day there are houses without number, in charge of men of great experience, whose sole business it is to import and "grow" orchids. Two of the largest in this country may be visited—one at North Easton, near Boston, the collection of Frederic L. Ames; the other at Short Hills, New Jersey, in the "United States Nurseries" of Messrs. Pitcher & Manda.

By cultivation, as in other plants, the number and size of blossoms can be increased. By crossing different species wonderful hybrid varieties are obtained, which bring fancy prices, sums which threaten to rival the golden guineas sunk in the ancient pots of Dutch tulips. From $500 to $1000 are charged for some hybrid plants which are mateless. Like "artist's proofs," they are valuable because rare.

On the other hand, one with moderate means may fill his small greenhouse and delight his æsthetic soul with a few delicate Vandas, gorgeous Cattleyas, lovely Dendrobicerns and Lælias, all for less than one rare oil-painting would cost. They are not suited to parlor gardening. Since it takes some years (from two to

eight) to develop a plant from its seed, unless hybrid varieties are desired, they are propagated by separating their bulbs.

As a table ornament and for ladies' evening wear, the orchid is the most durable of flowers. It does not wilt nor drop its petals. It is perfectly fresh at the end of an evening, and if then placed in water, will keep its beauty for three or four weeks.

Orchids are of two kinds, air-growing and earth-growing plants. The former, called epiphytes, are not necessarily parasitical. They fasten themselves to other plants, but extract their nourishment from the air by means of roots covered with a white spongy substance. These are swellings of the stems—pseudo-bulbs, as they are called—filled with nutritive matter. These Ariels of the flower world worm their threadlike roots around branches of trees, living and decaying; or they cling to bare rocks, throwing out curiously marked leaves, and long, slender, swinging scapes, with gorgeous, bizarre blossoms clustered upon them like butterflies; or one flower, a thing of beauty, will be lightly poised at the end of a wire-like petiole. The air plants abound in tropical countries—in Mexico, in the moist forests of Brazil, the thickets of the Orinoco, the valleys and mountain-sides of the Andes. Humboldt said that one life was too short to study the orchids of the Peruvian Andes alone. Java supplies three hundred species. In Ceylon, Assam, Madagascar, and now, says Stanley, in the forests of central Africa, wherever the climate is warm and moist, there they flourish. They are the

"weeds of the tropics." There are, however, species, even of the epiphytes, which seek a colder climate. They climb the mountain-sides, ten to fourteen thousand feet high. In Nepaul they are found in the cloud and shower belt, and terrestrial orchids abound in British America as far north as Alaska. A desert atmosphere alone seems to forbid their growth.

After blossoming, a season of rest is required corresponding to the dry season of the tropics. A lower temperature and less water afford this rest. The most successful florists have three different rooms, ranging from hot and moist to dry and cool, in order to suit the varying conditions and different species of their plants. The cool room faces the north, and is protected by whitened glass from the sun's direct rays.

The collecting and transporting of these plants is often attended with difficulty. Those which grow upon the ground, or upon low branches, are easily secured. But in order to obtain sunlight they often swing their glorious blossoms at the very top of tall trees, which to climb would be impossible, even if it were not dangerous. Venomous serpents may lurk in the crotches of the branches. Near the flowers, in order to subsist upon their nectar, a colony of ants may have made its nest. Their powerful mandibles take hold of a man's flesh and inflict a wound more painful than bees' stings. To secure the plant the tree must be felled, and the wood is as hard as iron. At the first blow the ants hasten down to punish the intruder. The wood-cutter will ply his last blows with the energy of agony, while swarms

of ants bite his legs. When at length the tree lies prostrate, the branch, with its contiguous ants' nest, must be separated from the tree. Then, by means of a lasso, it must be dragged to a neighboring stream, and snbmerged for hours before the prize can be claimed.

If the roots do not penetrate deep, the bark alone may be removed with the plant. Often the most ravishing species chooses an airy perch upon a perpendicular rock, over a cataract, and the collector dare not risk his life to secure it. Orchids love such spots, where they can perpetually bathe in falling mist.

Experience has proved that salt air is very hurtful to the tropical orchids, and they are best transported in close wooden boxes, whose seams have been hermetically sealed with tar, or better still, in glass cases. They are packed with moss, and carefully separated from each other.

The same insects—the red spider, wood-louse, small ants, the mealy-bug, etc.—which attack other plants, are destructive to orchids. Perhaps their worst enemy is the cockroach. This insect feeds upon the tender roots and flower stems, and does much damage in a single night.

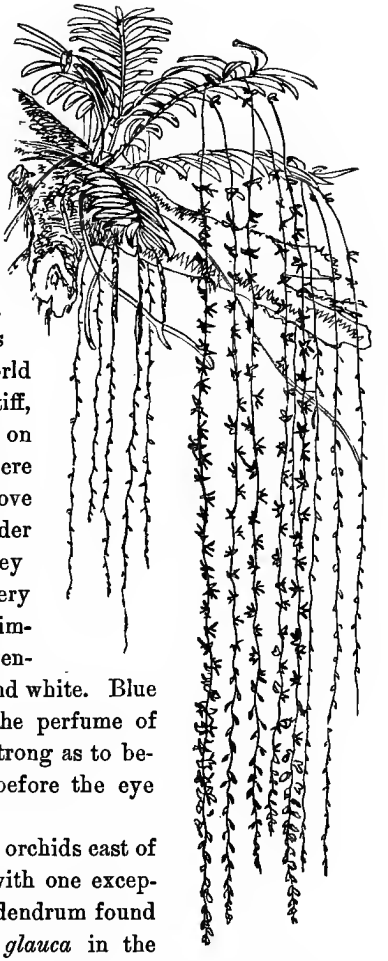
One of the earliest orchids to attract attention was the "Espiritu Santo," the Holy Ghost plant of Mexico. It simulates very perfectly a white dove sitting in the sweetest of nests, its head sunk upon its breast. It was regarded with reverence by the devout natives, who made the sign of the cross as they approached it. The Mexican lover sent it to his lady as a pledge of his affection.

It does not need a vivid imagination to see shells, insects, even miniature animals, in the fantastic arrange-

ments of these flowers. There are lizards, spiders, and humming-birds. Butterflies are so cleverly imitated that the insects hover around them as if to claim kinship.

Most of the orchids of the Western world grow straight, with stiff, erect stems. Those on the Eastern hemisphere are pendulous, and love to cling to the under side of a branch. They are painted with every shade of scarlet, crimson, pink, purple, lavender, brown, yellow, and white. Blue orchids are rare. The perfume of many orchids is so strong as to betray their presence before the eye has discovered them.

The United States orchids east of the Mississippi are, with one exception (a species of epidendrum found upon the *Magnolia glauca* in the Southern States), earth-growing



VANDA LOWII

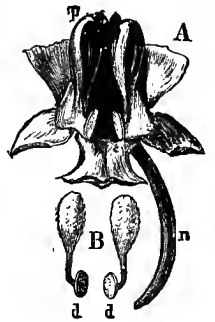
plants. Their flowers are by comparison dull and odorless, but they are all curious and full of interest to the botanist, whose pride and delight it is to have a complete list of specimens in his herbarium. Especially if he finds one marked "rare" in the botany, how lovingly does he dig it up by its bulbous root, and press it, and mount it, and refer to it afterwards!

There are now known to be several thousand species of orchids, grouped under three or four hundred genera, and these again are comprehended in seven tribes, four of which—Ophrydeæ, Neottieæ, Arethuseæ, Cypripedieæ—include our Northern species, more than fifty in number.

The characteristics of orchids can be understood even by those who are not botanists. Like lilies, their floral organs grow in threes. The perianth is composed of three outer leaves, which are usually longer and narrower than the others, and three within, all colored and petal-like. One of the inner set assumes a different shape from any of the others, and is termed the labellum, or lip. It is flat and broad, pocket or slipper shaped, often produced below into a nectar-bearing spur. It has colors of its own, is fringed or variously dotted, lined or grooved. By the twisting of the ovary halfway around, it is brought from the upper part of the flower, opposite the flower stem, to the lower part, opposite the flower bract. It thus furnishes a more convenient standing-place for insects which assist in its fertilization.

There should be six stamens, in two rows, but five

(four in Cypripediums) are suppressed. Two of the three pistils are also wanting. Some botanists regard two pistils as united into one, making a broad stigmatic surface, while the third becomes a rostellum, or little beak. The pistil is confluent with the stamen forming the column. The two anthers of the stamen lie one on each side of the broad stigma, hidden in little lobes or pouches. The pollen is aggregated into two or four masses by waxy threads, which terminate in a stem or caudicle, and a sticky, button-like disk. The column is thus the consolidation of all the sexual organs, and at once marks the orchid as singular. The long twisted ovary pod when cut across exhibits myriads of brown dustlike seeds borne upon three parietal placentæ—that is, upon the sides of the pod. Since the arrangement of the column is puzzling to young botanists, if the other marks exist, viz., the irregular perianth, the labellum, the twisted ovary, and especially if the stamens and pistil are not found separate, as in other flowers, the plant may be pronounced an orchid.




CONSTRUCTION OF ORCHID

A. Centre of flower (petals removed). p. Pouches containing pollen-clubs, with the two disks guarding the opening to nectary, n. B. Pollen-clubs isolated, to show their position in pouches, and their two glutinous disks, d d. The stigma of flower is indicated by the rough spot above opening to nectary.

All the orchids are perennials. They do not hurry

their lives into one brief summer, but, like the noble and stately forest trees, mature slowly and live many years. A Burmese plant was estimated to be over a hundred years old.

In one other respect they figure as aristocrats of the vegetable world. They are useless. Except the aromatic extract of vanilla, which is obtained from the dried and pulverized bulbs of the vanilla orchid of Central America, and a drug called saleb, now but little used, they have no utilitarian value. Theirs is the aimless life of butterflies. Swinging from their lofty heights, or nestled among ferns and mosses, they toss their peerless blossoms among the more sober medicinal and edible plants in disdain of any apology for their existence save beauty.

In size they range from the tiny tway-blade, a few inches high, to the gigantic oncidiums, whose golden panicles measure ten feet in length. Sobralias often send up stalks fifteen feet high. On a single plant of oncidium fifteen hundred blooms have been counted.

The expression "highly specialized," as applied to orchids, means that their organs are shaped and arranged with reference to special functions. This evident design with reference to an end has been partly explained in a previous chapter. The rich color and strong perfume, the varying shapes of the perianth, are in fact so many devices for attracting and accommodating insects. Self-fertilization is not desirable, in that it produces a weak offspring, likely to perish in the first struggles for existence Cross-fertilization can only be

effected by the visits of insects; consequently the invitations are urgent, and the entertainments furnished by their hostesses are most attractive to insect guests.

Flies and bees fertilize the smaller orchids, butterflies and moths the larger. They alight on the labellum, attracted by the fragrant nectar. Lines and grooves, called "pathfinders," guide the proboscis into the nectariferous tube in such a way that some part of the insect's head or thorax must press against the anthers. The viscid disks of the pollinia adhere to the insect. In some cases a membrane is ruptured by the weight of the insect bearing down the labellum, and the pollinia are shot with tiny force against the eyes of the entering moth. If time is necessary for the firm cementing of the disks, means are found for detaining the guest. The feast is not set out and ready. It is hidden at the bottom of a long narrow tube, down which the insect must crawl, and from which it must emerge backward.

More wonderful still, the coveted sweet is secreted between the inner lining and outer membrane of the tube (as in our own *Orchis spectabilis*). The insect must puncture and insert its proboscis into holes in order to obtain the nectar. Many pairs of pollinia have been found sticking to the proboscis of one butterfly, and since the insect contrives at times to remove them with its mandibles, it may be inferred that they are not regarded as wholly agreeable appendages. After being fastened to the insect's head, the pollinia droop and diverge in such a manner as exactly to fit and come in contact with the stigma of the next flower

visited by the unconscious insect agent. The broad stigma is very porous and viscid, and the pollen-masses, in part or entire, are held and absorbed. The tiny tubes of the pollen-grains press down into the ovary and search out the dormant ovules, which are only waiting for this magic touch to awaken into living energy. Sixty-two thousand seeds have been counted on a single plant, and it follows that there must be an enormous waste of seed, else the earth would quickly become carpeted with orchids. In fact, many flowers never receive the visits of insects, and do not become fertilized. How many perish in their infant struggles, in which only "the fittest survive," we can never know.

Since visits of beetles are injurious, their fat, hard bodies being likely to rend the delicate flower tissues, they are not invited. As in the fable of the stork and the fox, the honey in long narrow vessels is inaccessible to them, and they seek it therefore in flowers where it lies flat, and more or less exposed.

Of our native terrestrial orchids, among the earliest are Cypripediums, or lady's-slippers. The flowers of this tribe have two stamens, each bearing a two-celled anther; and a third stamen becomes, in the language of Dr. Gray, "a dilated, triangular, petal-like, but thickish body." There are six species. *Cypripedium spectabile*, the showy lady's-slipper, is the most regal. The lip is a rich pink, spotted with white, varying to pure white. It appears in June, in peat bogs, from Maine to Illinois. The *Cypripedium acaule* (stemless)

is found still earlier in the rich pine woods of Connecticut, Long Island, and New Jersey. Elaine Goodale places it on "rugged steeps" in her pretty lines about "The Indian moccasin":

> "We long with her to leave the beaten road,
> The paths that cramp our feet,
> And follow upward by the tangled wood,
> By highways cool and sweet,
> From dewy glade to rugged steep."

Not only "upward," but down by the shore of a New England lake, you may seek for it, resting yourself on the soft pine needles after your tramp. Look behind that skunk-cabbage, where the brooklet runs, where the lygodium ferns climb among mosses and silvery leaves, and, ten chances to one, you have a pink beauty for your prize.

There are two yellow lady's-slippers, fragrant, both with wavy leaves and petals. The smaller is richer in color. They often grow together upon knolls, under birches and maples, on mountain-sides, or in pasture-lands. If near them you chance to find one specimen of *C. arietinum* (ram's-head lady's-slipper) you may congratulate yourself, for this is "rare." It is small, purplish pink, its hairy lip white-veined. It grows as far north as Montreal, both on hill-sides and in low damp ground.

A bit of cotton inserted in the labellum of Cypripediums before pressing helps to preserve the color and shape of the slipper.

The *Calypso borealis* would seem from its slipperlike shape to belong to this tribe, but it forms with pogonias, calopogons, coral roots, arethusas, and others, the third tribe named after the Arethusa. The Calypso has but one stamen, with two anthers. The colors of the little shoe are most delicate—purple, pink, and yellow—and woolly hairs grow within like a felt lining. It is a small bog herb, but you would gladly pay the penalty of wet feet could you but secure this nymph for your collection.

> "The tints of purple and the texture fine,
> The curves of beauty seen in every line,
> With fringes exquisite of golden hue,
> Perfect the wonders of the fairy shoe."

The *Calopogon pulchellum* and *Pogonia ophioglossoides* are barbarous names for beautiful orchids, often found growing together in morasses covered with treacherous sphagnum. Calopogon means "beautiful beard," and the description in the botany reads, "Lip as if hinged at the insertion, and beautifully bearded towards the dilated summit with white, yellow, and purple club-shaped hairs." Country people call it "grass pink." Its peculiarity is that its ovary is not twisted, and the lip stands in its normal position in the posterior part of the flower.

A rare plant of this tribe is the *Aplectrum hyemale*, or putty root, or Adam and Eve. Its growth is singular. Every year it forms a small new bulb of solid nutritive matter, which sends up from a cleft a large

oval evergreen leaf, and the following summer a spike of greenish-brown flowers. It is this division of the bulb which suggests the common name Adam and Eve.

Similar in growth is the *Tipularia discolor*, the crane-fly orchid. It is very scarce, therefore doubly precious. The blossoms are greenish, tinged with purple, and the lip is provided with a "thread-like ascending spur" two or three times the length of the flower.

The Corallorhizas, or coral roots, may be root-parasitic. They have no leaves, but simple sheaths surrounding the rather dull scape of blossoms. The thickish roots bend and twist, suggesting bunches of coral.

The queen of this genus is the peerless *Arethusa bulbosa*, with her royal purple robe, the large hanging lips fringed with light purple and yellow. When at school in the pretty village of Norton, Massachusetts, I used to look forward eagerly to the time in early June when, shoes and stockings off, I might wade into the swamp some distance behind the seminary, and secure these water-nymphs, numbers of which would spring up and bloom in a single night. Clumps of the poison-sumac grew near, and the search had to be pursued with care. This orchid, "rather scarce and local," may sometimes be found in cranberry patches; but many botanists have never seen it growing.

The *Orchis spectabilis* is our one true orchis; the others should be written with a *d*—orchid. This appears towards the last of May. You must look for it

on cool hill-sides and in rich woods. It is a showy flower, as its name implies. It sends up a low stalk from a tuberous root, bearing pink, purple, and white flowers. The sepals form a sort of canopy over the column; hence one of its common names, "preacher-in-the-pulpit."

The genus Habenaria or rein orchis includes many of our handsomest species. Here are grouped the stately-fringed orchids—the white (*Habenaria blephariglottis*); the yellow (*H. ciliaris*), whose bright orange-colored flowers, the lips copiously cut and fringed, are very striking; the green-fringed (*H. lacera*) and the purple-fringed (*H. fimbriata*). These all produce conspicuously handsome spikes of flowers, rather late, from July to the last of August, in wet sandy places along the sea-shore, or in bogs, or by the sides of lakes. A specimen will almost leap into your face when you are searching for campanulas and other things that love the water-side, and you may then weary your life trying to find another. With myriads of seeds and such perfect contrivances for fertilization, I can never account for the loneliness of these larger orchids. It is part of their aristocratic nature that they will not become common.

Every one has found rosettes of thick white-veined satiny leaves in woods. The markings resemble snake skins, and so they are called rattlesnake plantains. The bluish leaf belongs to *Goodyera pubescens*, and is prettier than the one-sided spike of dirty white flowers which appears in July and August. The *Goodyera*

A GROUP OF NATIVE ORCHIDS

*repens* is of smaller growth, and the pretty leaf is covered with a yellowish satin gloss.

The Spiranthes, lady's-tresses, are among our commonest orchids, growing numerously in old orchards, by road-sides, in pastures and fields. By the twisting of the ovary, the flowers mount spirally around the stem. They are almost of waxy thickness and a dull greenish-white in color.

The Liparis, or twayblade, is a delicate, retiring little plant, found in cedar forests and under the mountain-laurel on rich hill-sides. The pyrolas and partridge vines keep it company, and Dicksonia and Woodsia ferns nod to its purple petals.

These are a few only of our terrestrial orchids. A complete description of the entire list would fill a volume.

If we would now behold the glory and beauty of the epiphytal orchids, we may visit one of our large houses devoted to their cultivation when the plants are in full bloom, say in February. As we enter, we are simply bewildered by the magnificence of the scene. The colors are beyond the power of paint-brush to copy, and the mingling of odors produces a delightful intoxication. We cannot tell which is the most ravishing—those large waxy white flowers, tinged with the faintest blush of pink, drooping from their graceful stem; or those royal purple beauties which seem to have borrowed all the shades of the garden pansies, and touched them up with still richer and deeper velvet hues; or those large crimson queens, shading from light to dark;

MASDEVALLIA DENISONIANA

or, again, those tiny salmon flowers, pendent from a board, and looking like bits of coral among sea-weeds. Surely, "Solomon, in all his glory, was not arrayed like one of these."

Then what floral curiosities! There are brown and yellow spiders with five long legs; green and brown lizards streaked with yellow. One, the *Masdevallia elephanticeps*, has three long onter floral leaves with appendages, which curve in such a manner as to imitate the tusks and trunk of an elephant.

While you are ravished with the sight, you hear with perfect calmness the attendant

LYCASTE

say, "This is the *Cattleya bluntii*, worth $1000; the only one in the country." If he had said $5000, it would not have seemed extravagant. Such unattainable, such unapproachable beauty ought to be priceless, as it is peerless.

The Odontoglossums comprise a very large and handsome genus. They are evergreen, and many of them, being imported from high lands in Mexico and Central America, will be found in the "cool house." One of the noblest is *O. pescatorei*, whose flowers are rosy white, the lip partly yellow. The *O. nebulosum* comes from an altitude of ten thousand feet.

The *Angræcum sesquipedale* is a striking importation from Madagascar. The flowers are ivory white, waxy, with a spur attached to the labellum, from ten to eighteen inches long. In its native country it attains great size, covering whole trees, and is an extraordinary bloomer.

The genus Cattleya includes one hundred and seventy-five species and many favorites. Most of them are grown in pots half-filled with broken pieces of pots, covered with peat or fern roots and moss. This potting material secures ample drainage and sufficient nourishment. The plants are raised well above the rim of the pots, and their roots can be seen twisting through the sphagnum moss. The foliage is often handsome, the leaves and pseudo-bulbs being unlike any of our Northern orchids.

A superb variety is *Cattleya trianæ* from New Granada. The plant often "sports"—that is, presents flowers

differing in color and size in different seasons. I saw flowers of a rich dark purple, but the type is said to be white sepals and petals, the lip blushing, with a crimson throat.

The flowers of *C. Mossiæ* are from five to eight inches across. They are a beautiful rose-purple, and the lip is streaked with yellow and purple. Nearly all the flowers in this genus are strongly and pleasantly scented.

The *Cœlogyne cristata* is a beautiful white orchid, with yellow lip. Six or eight flowers hang from a drooping spike, and they say "it is as easy to grow as a verbena."

The Vandas have a deserved celebrity. They are delicate and graceful. The name is from Sanscrit, and means the sacred parasite of the oak. The *Vanda tricolor* has a white perianth spotted with purple, and the lip is a deep violet marked with white. There are at least fifteen well-defined varieties of Vandas, some of which bloom the year round.

The *Vanda cœrula* from the East Indies and *V. cœrulescens* from Burmah are famous as being the only acknowledged blue orchids. The first is entirely blue, the lip deeper in color than the petals; the second has a large blue apron-like spot upon the lip. Both are rare. They, with many other kinds, are grown in baskets made of wooden slats fastened together with copper wires, leaving large spaces, and are suspended from the ceiling of a warm and moist house.

The *Vanda suavis* is from Java. Its leaves look like

LÆLIA PRÆSTANS

the leaves of cornstalks growing close together, clasping a thick stem, long, narrow, and drooping. The flowers are a light lavender, and there are darker spots on the lip.

It is simply impossible to enumerate even the well-known species of greenhouse orchids, and time fails us also to take a passing glance at the Cypripedium house, with its hundreds of varieties of small and large lady's-slippers, manifesting endless combinations of color and markings, and ranging in value from a few dollars to hundreds. Efforts in the hybridization of these plants have met with marked success. Patience and judicious fostering care on the part of those who love their plants with almost parental fondness seem to be rewarded with rare races of plants, a few of which are worth a fortune to their possessor.

# V

## LEAVES

Variety and Beauty of Leaves—Queries About Leaves—Leaf Album—Altered Leaves—Cellular Tissue—Arrangement of Leaf-cells—Stomata—Offices of Leaves—Metastasis—Arrangement on Stem—Devices for Protection of Leaves—Why Leaves Fall in Autumn—Carnivorous Plants

THEY who live in the perpetual green of the tropics, where the leaves decay and are replaced imperceptibly by a constant renewal of the plant's activities, miss our two most delightful seasons—the budding spring with its pale green and bronze tints, and the autumn with its gorgeous reds and yellows. Beautiful as is the summer, we would not choose it all the year round. In the resting-time of nature, town and city life attract us, and our social instincts are most alive. But when the first breath of spring is felt, and a faint shimmer of green spreads over the shrubs and trees of the parks, then the country and its miracles of new growth irresistibly attract us. An unrest pervades our city homes, and we desire nothing so much as to close the shutters and leave the homes, seeking for a grove where we may swing our hammocks, where the birds and flowers and lightly moving branches may afford us companionship and entertainment.

Have we ever thought how much of the pleasure of

country life is due to the trees and their leaves? Not only because they fan and shade us, but because they are beautiful with an endless variety of shape and size, they gratify our æsthetic fancies. In a single short walk one will see the oak leaves, stiff and hard; the hornbeam, deeply furrowed; the aspen, small and delicate, hung upon a stem flattened contrary to their own planes, and therefore shaking as if with palsy; the spreading horse-chestnut; the dark green, handsomely cut maple and poplar—all combined into heavy or light masses of waving green.

It goes almost without saying that we ought to know the names of our most common trees, and the general functions and purposes of leaves. If a good botany and microscope go into our trunk as part of the summer's outfit, we shall need no other teacher than our own observation.

Certain queries about leaves will naturally arise the moment we pluck and look at them with reference to exploring their secrets. What are they? Why are they necessary to the tree's life? What are their special functions? Why is the upper side a darker green than the lower? Why, if covered with dust, will they die? Why does drouth or lack of sunlight turn them yellow? Why do they fall in autumn? To answer, we must peep into the wonder-chambers of nature. They are hidden and small, but the microscope, the great revealer, will disclose movements, chemical transformations, wonderful adaptations of means to ends, that we have never dreamed of.

Every child may know the common facts about the exterior of a leaf. The terms used in describing its shape and outline are not arbitrary, but those which are naturally suggested.

Let the children make a leaf autograph book. Nothing can better combine pleasure with profit. Under a pressed leaf fastened upon a page may be written a complete description of the leaf, height of tree or shrub, color and smoothness of bark, where found, and when.

A parallel-veined leaf indicates that the plant is endogenous, like the lily, corn, grasses, and plantains. A netted-veined leaf, according to the shape, is either feather-veined, where the veins all spring from the mid-rib, or palmately veined, where they spring from a common point, and radiate like the spread fingers of the hand.

In general outline they are narrow and long, varying to round. The terms linear, lance-shaped, oblong, elliptical, ovate, orbicular, mean in botany just what they do as plain English adjectives. When the base narrows, put the syllable "ob" before the term, signifying inverse; as oblanceolate, obovate. If the base has projecting lobes or ears, call it heart, arrow, halberd, or shield shaped. The apex is tapering, acute, blunt, truncate (as in the tulip-tree), etc. The edges are entire, serrate (like teeth of a saw), dentate (toothed), crenate (scalloped), wavy, smooth. When lobed, write how deeply, as lobed, parted, cleft, or divided. Leaflets are little leaves when the division extend to the petiole.

Suppose the leaf of a sugar-maple be chosen to describe. The descriptions would run somewhat as fol-

lows: Arrangement on stem — opposite. Petiole — rather long. Stipules—none. Lobed—palmately. Divisions—3–5. Veins—netted, palmately. Outline—serrate. Base—truncate. Size of tree—large.

Let the description continue: "We held a picnic under this tree;" or, "I saw a squirrel or a bird's-nest on this tree."

Nothing will cultivate the faculty of observation in children like the leaf album, and useful knowledge is in such ways pleasantly acquired.

What is a leaf? Shall we say, in semi-scientific language, a green expansion borne upon a stem produced at regular intervals along the branch? This will describe a chestnut leaf; but since, botanically considered, there are but three parts to a plant—root, stem, and leaves—other things besides the "green expansions" must be leaves. Flowers and fruits are altered leaves. In some plants, as in *Castilleia* (scarlet painted-cup), the gradual change of foliage leaves into sepals and petals can be traced. In the water-lily the petals gradually become stamens. There are "monstrous flowers" found almost every season in which the pistil, instead of forming fruit, grows into a small leafy branch. Roses, strawberry, pear, and cherry blossoms exhibit such peculiarities, enough to sustain the botanist's view that pistils are forms of leaves. The pod of a pea or bean naturally suggests a folded leaf. The layers of an onion bulb and the meat of a nut are leaves fattened with nourishment stored thus for the plant's use. Stems and roots also store up starch as well as leaves. The sweet-

potato is a root, but the Irish potato is a thickened stem, and its eyes are buds. Tendrils and spines are sometimes leaves, sometimes altered branches or stems. Their place must determine this. If they appear on the joints or "nodes," they are leaves; if in the leaf axils — that is, the upper point of contact of the leaf with the stem — they are branches. The leaf bud formed in the fall contains, in some trees, all the nodes and leaves of the branch which is to grow the following summer. The length of stem between the nodes depends largely upon cultivation. The internodes of the apple-tree in the orchard are much longer than those of the crab-tree in the pasture. All such buds are protected from the frost of winter by strong thick scales, which are also forms of leaves, and which fall off in spring. This is called determinate growth, and the branches of such trees and shrubs often attain their full length in a few weeks' time, beginning in midsummer to form the next year's buds.

Indeterminate growth is like that of the honey-locust and sumac, the raspberry shoots and perennial herbs. These grow until arrested by the cold of autumn, and form no axillary buds for the next season. In such the upper parts of the branches generally die down, and new growth the next spring takes place from the lower axillary buds.

The upper leaves on a barberry branch become spiny, and at length spines pure and simple. Thorns and prickles are elongations of epidermal cells. The essential part of a leaf is the blade, which presents a broad

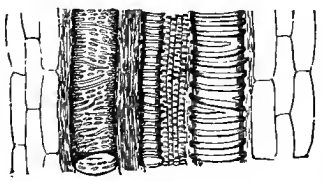
surface to the air and sunlight. The petiole is sometimes wanting, and the leaf becomes sessile. Sometimes two opposite sessile leaves meet and envelop the entire stem with their cup-shaped bases. Such are the upper leaves of the trumpet-honeysuckle. The petiole may expand and become bladelike.

The pair of leafy appendages found at the base of quince and clover leaves are the stipules. They assume varied forms, and are often wanting altogether. In the tulip-tree and magnolia the stipules are the bud scales, and they fall off when no longer needed. In the locust they are thorns, in the pea they are broad and leaflike, in the buckwheat they clasp the stem like sheaths.

It is impossible to understand what a leaf does for the tree, unless we know something about cellular tissue and the formation of plant material by the plant itself.

Roots, stems, and leaves are aggregations of cells. These cells, at first simple, as in the lower orders of plants, become in plants of higher orders "differentiated," and assume various shapes and sizes. By simple pressure against each other, they become flattened and many-sided. Cellular tissue, with spaces for the circulation of air, is called parenchyma; and this comprises the greater part of plants surrounding other forms of tissue. The tough framework of a tree is made of threads united into bundles—long drawn-out cells whose walls have become hardened. These "fibrovascular bundles" run through the main stem and leaf petiole, forming the framework of the leaf, the veins which support and hold together the softer cell tissues. If a

horse-chestnut leaf be broken off, dot-like scars will be seen upon the trunk where the threads have been severed. Vessels or ducts necessary for the freer conduct of water from the roots are cells joined lengthwise, with their division walls absorbed. These, by an uneven deposit of cellulose (the material of which cells are made), are dotted or marked with rings or spirals. Cells are more crowded and compact in the newer than in the older parts of a tree. Intercellular spaces filled with air are necessary for the plant's existence. These air galleries must so connect that there shall be uninterrupted communication from leaves to root.



WATER-CARRYING DUCTS OF PLANTS

A living cell contains a whitish, almost colorless fluid, called protoplasm. Within, not always in the centre, is a dark spot, the nucleus. Here we stand face to face with plant life. We may see it through the microscope, but who shall say what it is? Magnified five hundred times, protoplasm is resolved into fine threads, which are seen beaded with minute dots, constantly, restlessly moving up and down. They move not only in their own cells, but pass through thin walls into adjacent cells. In defunct cells there is no movement of the protoplasm, and in an exogenous tree the greater part is "dead-wood."

Says Dr. Asa Gray: "The plant is a composite being or community, lasting, in the case of a tree, through an indefinite and often immense number of generations. These are successively produced, enjoy a term of existence, and perish in their turn. Life passes onward continually from the older to the newer parts, and death follows with equal steps, at a narrow interval."

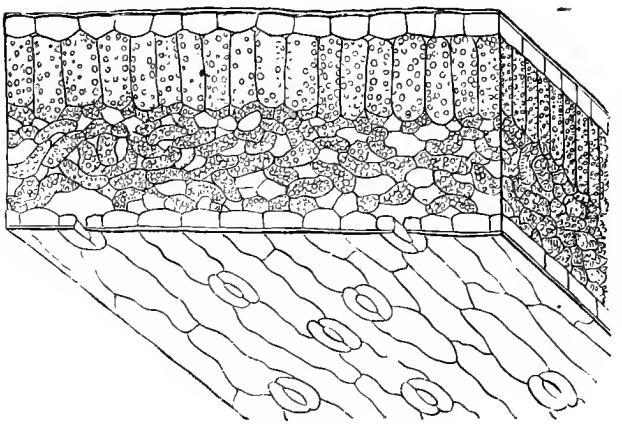
A ring of living cells surrounding the dead heart of the tree is the medium for the circulation of sap. The next year this ring is dead, and a new, living ring is formed. Were it not that storms destroy forest trees, theoretically they should live forever.

Let us now examine leaf cells. Cutting through a leaf, and looking at the edge through a microscope, we find the cells on the upper side closely packed, standing up (so to speak) in rows. The lower cells lie down, and are more loosely thrown together. Being filled with grains of chlorophyl (leaf-green), a more solid green is formed on the upper side. The whole leaf is covered with the transparent cells of the epidermis, and the veins and veinlets—the woody part—ramify through them.

In order to throw open the air-galleries of the plant to the air, hundreds and thousands of little doors, or mouths, are found, especially upon the lower side of the leaf. They are the stomata (singular, stomate); literally, the breathing-pores of the plant. If we think of them as mouths, they are protected by a pair of lips (curved cells), which open or shut at pleasure. Through these stomata not only air but moisture is breathed in

and out. In wet atmospheres the "guardian cells" are wide open; in times of drouth, shut. Thus, in dry seasons, by preventing the escape of the water already within the plant, the thirsty little cells are partially satisfied and life is prolonged, when otherwise the plants would die.

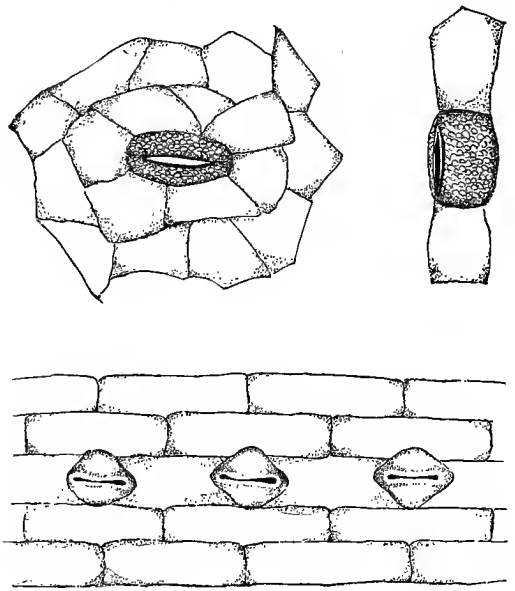
The number of these stomata is marvellous. In a square inch of an apple-leaf there are from twenty to a hundred thousand. The fuzz, or bloom, so often found



HIGHLY MAGNIFIED SECTION OF LEAF,
Showing longitudinal arrangement of upper cells, and stomata on lower surface

on the under side of the leaf, is a forest of fine hairs, designed to protect the stomata by warding off dust and other foreign particles. We now see why the lower

leaves of our begonias and other garden plants should be washed after a hard shower. The stomata are choked with earth spattered up by the rain, and when neither air nor moisture can enter the leaf, it must die. The

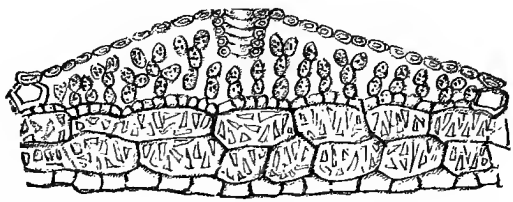


STOMATA

stomata do not like direct sunlight, so they seek the under part of the leaf. In aquatic plants, where the leaf lies upon the water, they are found upon the upper side. Some leaves which hang vertically, their edges upward,

as in the famous compass-plant of the prairies, have them equally upon both sides, and then the two sides of the leaf are the same hue of green.

The leaves, then, are the lungs and stomach of a plant. The plant lives on air and water. We, and all



PIECE OF LIVERWORT LEAF CUT DOWN THROUGH THE MOUTH

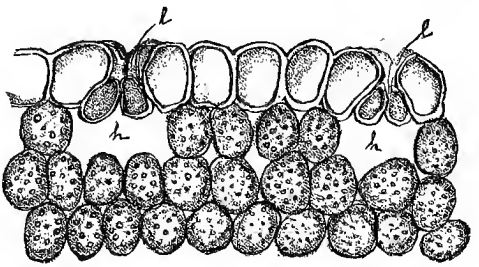
animals, live on plants, either directly or indirectly. Their tissues supply the flesh and muscles, and even the greater part of the bones of animals. And as plant food is inorganic—that is, water and air—they (the plants) form the connecting link between the other two kingdoms.

The moisture soaked up by roots contains minerals, such as iron, sulphur, magnesium, and phosphorus. Water rises in the plant, partly by capillary attraction, partly as water is raised in a pump. The constant evaporation from the stomata of the leaves sends a call through the succession of cells down to the roots for more to fill the tiny vacuums. The water exhaled from the plant is pure, leaving the minerals deposited like incrustations upon the cell walls or as crystals. Some

plants contain large numbers of crystals of different shapes whose use is scarcely understood. The amount of water transpired from a plant of considerable leaf surface is surprisingly large. By experiment it has been found that a sunflower, three and one-half feet high, on a warm day, transpired one pound fourteen ounces of water in twelve hours.

The minerals abstracted from the soil and deposited in the plant turn to ashes when the plant is burned. They form about seven per cent. of leaves, and two per cent. of stems.

The principal food of plants is carbon, taken as carbonic acid from the air, and dissolved in water from the soil. Animals throw this out from their lungs, supply-




BLUE-FLAG

*l l*, lips; *h h*, hollow of the mouth

ing it to the air. To them it is poisonous, and its accumulation, which in time would be fatal to animal life, is prevented by this simple but wonderful provision, by which the vegetable world requires carbon out of which

to build its fabrics. Here the chlorophyl grains of leaves (and other green parts) perform their most important function. In sunlight they become chemical agents, separating the carbonic acid into its two elements, oxygen and carbon, setting free the former, retaining and making use of the latter. Sunlight is absolutely necessary for this work. With the first rays of the morning the little laboratories begin their labors, and cease when the darkness comes. Cellulose (cell walls) is formed of carbon, with the addition of hydrogen and oxygen—that is, water. Nitrogen added to this compound (taken from air and rich soils) forms protoplasm, and from these two, cellulose and protoplasm, we have the basis of all vegetable and animal tissues. The process by which a plant converts earth, air, and water into its own tissue is called assimilation. Animals cannot assimilate. They digest; that is, convert organic materials into parts of their own bodies.

The plant by a further process known only to itself, called metastasis, can change cellulose into starch, sugar, etc., and protaplasm into albumenoids, such as glutens, oils, etc. Thus we obtain many valuable drugs —opium, aconite, cinchona, strychnine, etc. Oils are found in certain seeds, like the castor-oil and flaxseed, or in the fruit, as olive-oil. The grains—corn, beans, pease, rice, potato tubers, etc.—are so many deposits of gluten or starch laid up for the use of the young seedling. Sugar from beets, the sugar-cane, and sugar-maple, all such staples of food and articles of commerce, are made principally by the leaf chlorophyl

grains, and these different products are interchangeable at the plant's will. Thus sugar can be made into starch, and *vice versa.*

The arrangement of leaves on the stem is governed by certain inexorable rules. In general they are either opposite or alternate. Leaves are opposite when each node bears two, a half of the stem's circumference separating them. The second pair will then be above and at right angles to the first, the third pair directly over the first, the fourth over the second, and so on.

In the alternate arrangement the third leaf stands above the first, the fourth above the second, etc., and each second leaf is separated from its nearest neighbor by half the circumference.

One of the most common arrangements is that in the apple and cherry trees, and it may be represented by the fraction $\frac{2}{5}$. That is, two-fifths of the circumference separates each leaf from its nearest neighbor, and a line will go twice around the stem before the sixth leaf is found above the first, the seventh above the second, and so on.

Whorled leaves, like those of the common galium, are where three, five, or a larger number of leaves springing from the same node divide the stem equally between them.

Pine and larch needles grow in a cluster or fascicle from the same node, which is regarded as a shortened branch.

Much is done by Mother Nature to insure the protection of her delicate leaf children. The fine fuzzy

growth of hairs on the under side of many leaves has been spoken of as keeping dust and foreign particles from entering the stomata. Many leaves when in bud, and tender, are clothed with woolly hairs, which drop off when the leaf becomes older and stronger. By a thick growth of hairs, leaves are protected from the ravages of insects. Most plants which appear in early spring, in advance of the ants and larvæ of beetles, are, as might be expected, smooth or glabrous. Spines on leaves keep cattle from browsing upon them. Sir John Lubbock says that the upper leaves of the holly, which grow beyond the reach of cattle, are almost destitute of spines. The smoothness of evergreens is their protection, enabling them to shed snow easily, otherwise they might be broken down by the weight of snow masses. The same leaves are tough and leathery, in order the better to stand the wear and tear of six, or seven, or sometimes ten years of life.

It almost seems as if nettles and thistles, the soldier class, were designed as protectors of a whole neighborhood of defenceless plants. A daisy may grow quite safely near a thistle or under a bramble. One of the wickedest plants is the cat-brier, of the smilax family. When one of these matted, prickly vines has planted itself directly across your pathway it is better to go around, nor seek for treasures which can only be obtained by passing through the thorny branches.

The stinging-nettle (*Urtica dioica*), like some other European importations, is a very undesirable immigrant. The plant (as all the species of Urtica) is cov-

ered with fine hollow hairs, at the base of which are glands secreting a poisonous fluid. The point of the hairs is as sharp as a bee's sting, and penetrates the skin upon the slightest pressure of the hand, when the poison from the gland below flows upward into the blood, often producing very serious consequences. The nettle loves the rich soil of old barn-yards, and generally indicates large quantities of nitrogen in the soil. The *Lamium album*, a perfectly harmless member of the Mint family, resembles the Urtica so closely in its foliage that botanists will seldom venture to pluck it, unless it be in flower, when its liplike corolla indicates its true character.

Do leaves best fit their own trees? This can be most easily answered by placing a branch from one tree among the leaves of another. This has been done. Ash leaves have been placed among horse-chestnuts, maples among hickories. They will leave great spaces unoccupied, or else overlap. Nature is economical, and knowing that the good of the tree is best subserved by the presentation of the greatest possible area of chlorophyl grains to the air and light, it is wonderful how, with reference to this end, she has adapted to one another the leaves, branches, and trunk of every tree. It is one of the evidences of design on the part of an intelligent Creator.

It is generally supposed that leaves fall in the autumn because they die of old age. This is not a correct view. If we break off a leafy branch, the leaves will soon wither, but not drop off. In fact, they will cling to

the dried branch with greater tenacity than when they were green and alive, requiring some force to wrench or twist them off. In tropical climates they remain green much longer than in temperate countries, and their fall, when it does take place, is not just before the cold season, but during the hot, dry season. Many of our own trees, as oaks and hornbeams, retain their leaves dried and withered till the pressure of the new distending bud in spring displaces them.

As in man, the seeds of his decay are born with him, so in the leaf-bud there may be discovered the rudiments of a very delicate layer of cells, whose plane is at right angles to the plane of the leaf. When the time comes, this upright growth of cells enlarges, pushing from above downward, cutting through the woody fibres of the stem like a knife-blade. Thereafter,

"At every gust, how the dead leaves fall!"

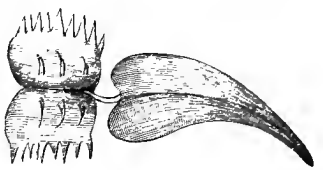
I have said that the food of plants is air and water, and that by assimilation the plant converts inorganic substances into organic, the leaves, by means of their chlorophyl grains, acting as the principal agents in this work. Besides, some leaves actually digest in the same way as our stomachs. The remarkable plants known as carnivorous, by means of glands upon the surface of their leaves, exude an acid ferment upon living insects, bits of raw beef, the boiled white of an egg, etc., which dissolves such animal food, after which it is absorbed into plant tissues.

The most ingenious devices are presented by such

plants for alluring and entrapping their prey. Bright-colored and often large blossoms, red and white veins in the leaves, honey-paths leading into the traps, entice insects as the lamplight does a moth, and rarely does an insect yield to the temptations and enter the trap so neatly baited without paying the forfeit of its life. Dry and hard parts of orthopterous and coleopterous insects drop around the roots and form manure. It has long been known that fungi live on decaying animal and vegetable matter, and that parasitic plants steal the juices of other plants. Such possess no chlorophyl grains, and are red, yellow, brown, gray, or white, but never green. They do not assimilate. But that some green plants should thrive upon animal food, actually preying upon insects, was deemed a romantic story until the appearance of Darwin's book on insectivorous plants, in 1875. His experiments were so carefully conducted as to leave no doubt of their scientific accuracy, and since then a host of observers has been attracted to follow in the same line. Among the enthusiastic workers is Mrs. Mary Treat, whose observations upon Florida species of Drosera, Dionæa, Utricularia, Pinguicula, and Darlingtonia, transplanted to tubs and basins of water in her study, and observed night and day, form most entertaining reading. In the interests of her studies she procured eggs of the mosquito and cheironomus, in order that she might see the larvæ enter the bladders of Utricularia. She filled her rooms with flies, and watched them entrapped by the Dionæa (Venus's fly-trap). She took cheerfully the stings of

yellow-jackets and bites of flies. The small hours of the morning often found her at her post, forgetful of the passage of time. One of her experiences is so singular it is worth quoting. (*Home Studies in Nature*, p. 186. Harper & Brothers. 1885.)

"That I might the more fully test the strength and power of the plant, I one day placed the tip of my little finger in the trap (Venus's fly-trap), resolving to become a self-made prisoner for five hours at least. I took an easy-chair and let my arm rest upon the table and my hand upon the edge of the pot, and with plenty of reading-matter before me, what should hinder me from keeping my resolve? In less than fifteen minutes I was surprised at the amount of pressure about my finger, and for more than an hour the pressure seemed slightly to increase; but by this time my arm began to pain me. Here is a problem for the psychologist. Was it the knowledge of my being held fast that caused



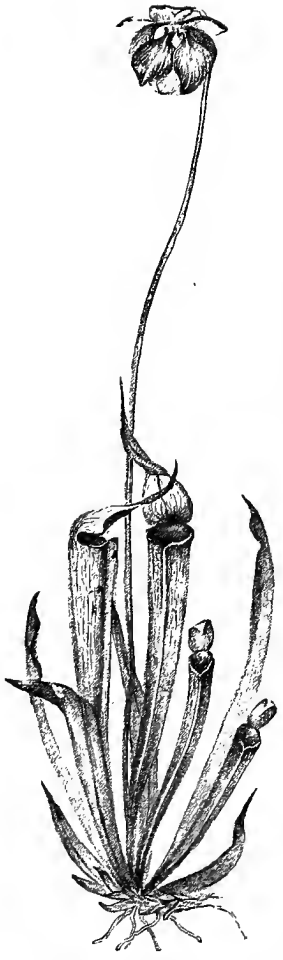
LEAF OF VENUS'S FLY-TRAP (DIONÆA)

THE SAME CLOSED

the pain? Surely I have kept quiet longer than this without discomfort. In less than two hours I was obliged to take my finger from the plant, defeated in so simple an experiment, and heartily ashamed that I could not better control my nerves. The slimy secretion had commenced oozing slightly from the inner surface of the trap, and if I could have kept the position for five hours, I presume it would have been much more copious, the plant not knowing but that I was as good to eat as a bug."

All the carnivorous plants love wet places, either growing in water or in marshes or upon wet rocks. This is necessary, in order that they may obtain that abundant moisture which is requisite to their glandular secretion.

The Utricularias, or bladderworts, float in stagnant water, where there is plenty of animalcules and insect larvæ. The finely cut leaves bear little bladders about one-tenth of an inch in length, which seem to serve the double purpose of floating the plant at its time of flowering, and of stomachs for the digestion of animal food. The orifice of the bladder, or utricle, is provided with six or seven waving bristles. These may serve to entangle unwary larvæ swimming near. If the larva ventures either its tail or head into the mouth of the utricle, it is sucked in so quickly that the eye cannot follow the motion. The mouth then shuts like a valve, and the creature cannot escape. The secretory glands at once begin to pour their fluid upon the prisoner,



PITCHER-PLANT IN BLOOM

which seems almost instantly paralyzed and incapable of motion. If a larva is half-caught within the trap, only that part without can continue to wriggle for a short time. A terrestrial species bears bladders upon a creeping underground rhizome, and these are found to contain the remains of small earthworms.

A near relative to the bladderworts is the genus Pinguicula, or butterworts. They grow upon damp rocks. The leaves grow in a cluster around the flower scape. The edges of the leaves curve inward, and are dotted with viscid glands. When a fly alights upon the sticky surface of the leaf, its edges fold more and more inward, till they touch and wholly cover the fly. In a short time the insect is dissolved and absorbed, when the leaf opens, ready for another. Spiral threads along the mid-

rib and lateral veins enable the leaf to curve and uncurve. Our only species, and that but seldom found, is *P. vulgaris*. The leaves feel greasy to the touch; hence the name, from *pinguis* (fat).

Of pitcher-plants there are many varieties. The pitchers are transformed leaves, all cup-shaped, holding water, in which insects are drowned, the upper parts provided with downward-pointing stiff hairs, preventing the insect from crawling back. The secretory glands are usually near the base of the receptacle.

In Sarracenia the leaf apex forms an overhanging lid, which partly excludes rain. Along the entire edge of the leaf is a cord or broad wing, besmeared with a sweetish fluid which both attracts and intoxicates insects. Flies try to stand on their heads after having sipped this honey; ants behave in an excited manner. All crawl up the leaf, pause a minute upon the rim of the pitcher, them tumble to the bottom, where they lie in heaps, too many for the plant to digest before their bodies become putrid. Then a foul smell comes from the leaf. The process of absorption of this decaying mass continues, so that the Sarracenia may be likened to the buzzards and vultures of the animal world, the carrion-eaters. Even large insects like cockroaches and hornets are found drowned in this

LEAF OF THE SARRACENIA

terrible vegetable trap. One species, *Sarracenia purpurea*, is found in our own swamps, generally with the pitchers half full of water.

The Darlingtonia is a twisted long and narrow tube, covered with an inflated hood, with two forked appendages like a fish's tail. The edges of the hood and mouth of the pitcher are covered with the honey bait.

NEPENTHES

In Nepenthes the petiole becomes broad and leaf-like, then tapers into a tendril-like body, which supports the true leaf as a pitcher. This is found in swamps of the East Indies, China, and the Malay Archipelago. It produces long and short pitchers, the latter growing near the ground and attracting crawling things, the former swung higher for flying insects. Small birds even are entrapped by this fiercest of plants, and a row of incurved hooks around the opening prevents the escape of even the largest prey. It is said that a black ant perforates the stalks of some of these leaves, and tunnels upward as far as the bases of the pitchers, in order to feed upon those insects that may drop down.

The cephalotus presents both ordinary forms of leaves and short broad pitchers provided with lids.

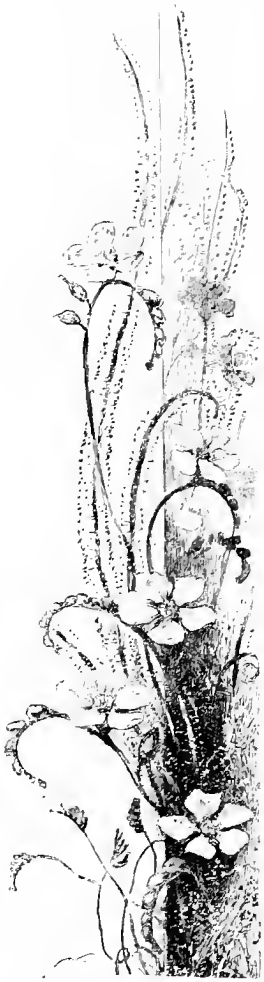
In Guiana the heliamphora is found. In the midst of the pitchers a delicate nodding spike of pink flowers grows. This plant is common with our florists. The tree-pines, Tillandsias, of South and Central Amer-

ica and the West Indies, have leaves dilated at the base, forming cups capable of holding rain-water. These cups of water would be a great boon to thirsty travellers were it not for the insects drowned therein. They are only a variation of the pitcher-plant. A species of bladderwort grows in the small pool formed by these cup-shaped leaf bases, and is in turn nourished by animal food. It sends out long runners which seek the nearest leaf of Tillandsia, there forming a new plant. Even different trees are sometimes connected in this way.

The Drosera and Dionæa are well known. By means of glands at the end of sensitive hairs a fly alighting upon a leaf of sundew is clutched by the long hairs bending over it, pouring their juices upon it, digesting and absorbing the insect's soft parts. When the work is done, the glands straighten, and are ready for more victims. After digesting a limited number of insects, the leaves of Drosera seem to lose their power of further action, turn yellow, and die, new leaves from the root coming up to continue the work.

In Dionæa the blade-like petiole is not sensitive. The leaf itself is like a half-open book. If an insect alight upon either face, the two parts of the leaf spring together like a book shutting, and spikes growing along the edges interlock and hold the insect a prisoner. Very small insects do sometimes escape.

It has been ascertained that all this class of plants thrive best when fed upon animal food. Of the fed plants the average weight of their seed to that of the



DROSERA FILIFORMIS

unfed is as 157 to 100; the number of seeds is as 240 to 100; the number of flower-stalks as 165 to 100; their total weight as 230 to 100. An insect-eating plant is therefore, we may say, twice as vigorous when fed upon insects as one of the same species that is not.

It is a singular retaliation of the vegetable world upon its natural enemies, the insects, whose larvæ feast upon the young leaves and twigs of our forests and orchards. And it is a poor return for the services rendered by the seekers after honey and pollen, which help to fertilize and spread the seeds of countless numbers of plant species. It does seem as if we must regard the insect-destroying plants as monsters of the vegetable world, things with perverted natures, the exception to all that is lovely and interesting in plant life.

## VI

## PLANT MOVEMENTS

Motion of Seed When First Planted—Circumnutation—Movements of Root-tip—Of Climbing Plants—Sleeping Leaves

All living things have the power of motion. A rock is motionless because it is a dead, inert piece of matter. Plants and animals, being alive, possess in common the ability, impelled and guided by some inward power, to move. Not all animals can move from place to place. Many lower orders, like sponges, are fixed to one spot, and can only attract nourishment to themselves. The movements of some plants are so remarkable that it is difficult to believe they are not guided by a sort of intelligence. In many of the lower grades of plants movement seems free and voluntary. The boat-shaped desmids and diatoms jerk themselves over considerable distances. The cilia (hair-like processes) of some mosses move about in water. Oscillaria are curious one-celled plants which, under the microscope, look and wriggle like angle-worms. They are filled with protoplasm, that mysterious something in which lies the life of both animals and plants.

As soon as a living seed touches the ground, or is buried beneath the soil, the plant germ struggles in-

tensely to free itself from its prison within the hard, dry seed coats. Life, hitherto dormant, and motion begin. Nature has endowed her tiny child with many wonderful provisions for the hard battle which it has to fight for very existence. The sun, air, moisture, and earth are friends and supporters of the little seed. Earthworms, destructive insects, burrowing animals, drought, cold, and hard impenetrable soil are foes against which the baby plant will hardly prevail. The successful seed patiently and persistently pushes its way, overcomes obstacles, appropriates suitable nourishment, grows, blossoms, bears fruit, and fulfils the plan of its life, whether it be a tiny portulaca seed or the winged samara of the haughty maple. Many more seeds perish than conquer in the struggle. The strongest and most favorably situated are those that survive.

Suppose we try to follow a young seed in its efforts to grow. The part which first "feels the thrill of life" is the tip of the radicle, or root. This is a wonderful organ, on which at the start everything depends. Mr. Darwin calls it the brain of the plant. Protected by a cap of hard cells, it pushes towards the centre of the earth, possibly acted upon by the attraction of gravitation. Instead, however, of going straight down, it feels around in an irregular, circular movement, as if trying to find the softest, most friable soil. If you are pushing your finger into the ground, see how much easier it is when moving the finger around while pressing downward than when pushing straight and steadily in one direction. Sometimes the circuit traversed by the

radicle tip is narrow like an ellipse. Sometimes it is almost like movement back and forth on a straight line. The movement is called nutation, or nodding. Darwin prefixes circum, making the word "circumnutation," "nodding all around." All growing parts of the plant —its stem, leaves, flowers, as well as roots—are in constant nutation, "bowing" to all points of the compass in turn, making longer or shorter ellipses, with greater or less regularity. According to the inherited habit of the plant, this revolving motion is, on the outward curve, from right to left, or from north to west, south, east, and north again, all its parts (when not disturbed by wind) revolving the same way; or the motion is in the opposite direction, from left, on the outward curve, to right. This will be perceived when we remember that all pease and beans, grape-vines, and other climbers twine in the same direction. This twining is but an exaggerated circumnutation.

To go back to our root-tip. In its downward course it strikes a stone. Immediately the tip is turned at right angles to its former course. It does not like the stone, and dodges, assuming a horizontal direction. What shall hinder it from keeping on in this newly acquired direction? Does it know when it has passed beyond the stone? Not exactly; but the part of the root just behind the tip knows. It hugs the hard thing which the tip hates, and curves over the edge of the stone, pointing the tip of the root once more in a perpendicular direction. Is there anything more marvellous than this divergent action of the root-tip and the

part directly, say half an inch, behind? It is almost as if two brains dwelt in the plant.

Secondary roots, developed from the primary, tend obliquely, not straight, downward, else all the roots would lie bunched together. Tertiary roots, developed from secondary, spread horizontally outward, and thus the combined roots use all the soil within their reach. All these movements of roots are determined by themselves. External influences, as a moist soil, or a ray of light penetrating the ground, produce still other movements of the sensitive tip, causing it to bend towards the moist soil and away from the light.

Almost simultaneously with the starting of the radicle for the earth, the caulicle or stem which carries the first two leaves (or one leaf in monocotyledons) has an impulse from within prompting it to seek for light. It arches its back in order to push with more force against the opposing mass of earth above. The two legs of the arch gradually elongate, the middle of the arch circumnutating and pushing upward until it breaks through the soil. Then, and not before, the stem straightens, and the cotyledons are brought into an upright position. The illustration of Darwin's, often quoted, is of a man over whom a load of hay has fallen. In order to extricate himself, he will first get upon his hands and knees, and with a wriggling motion from side to side will push with his back upward till he has broken through the hay, when he will draw up his body and stand erect.

A seed never makes a mistake by sending its roots

upward through the soil and its caulicle downward. One or the other or both may have to wind quite around the seed before they are rightly started, and such curves are often noticed. A lady, in most respects intelligent, told me that it made no difference how one planted vegetable seeds, with the exception of melons. These, she said, if planted upsidedown, would be killed. The statement is one of many made by really observing people, who are yet ignorant of the simplest facts about plant life. If true, there would be no explanation possible, any more than of the statement made and believed by many farmers, that corn which is not planted in the last quarter of the moon will be attacked with blight.

I have said that the habit of circumnutating can be best observed in climbing plants. Such, by means of a curving of the stem, or of tendrils, or of leaf-stems, coil around supports, and tightening, draw the entire plant upward. The morning-glory revolves from east, through north to west, and south to north again; or from right outwardly to left. The young stem makes short coils, the older ones longer. But the tip of the young growing stem is ever stretching out and feeling for something around which to coil. Often such stem-tips are hooked, the better to hold against the wind to their supports. When the plant climbs by means of tendrils or leaf-stems, these describe large circles in the air until the support is clasped. It is said that in the tendrils of the passion-flower this circular movement can be seen with the naked eye, as easily as the

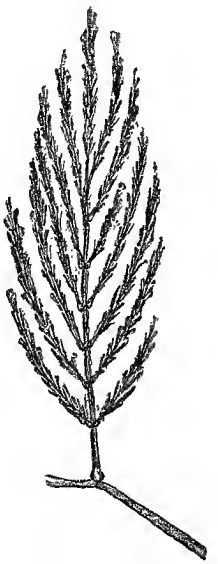
movement of the second-hand of a watch. Some plants have a different and peculiar means of taking hold of upright supports. By means of numerous rootlets springing from the stem, the poison-ivy clings to rocks, fences, the bark of trees, etc. The Virginia-creeper puts out tendrils which spread their tips against a flat surface in little adhesive suckers or disks.

MIMOSA AWAKE

When we speak of spontaneous leaf movements we enter verily into the domain of fairy-land. How many of us, when children, delighted to touch the leaflets of the sensitive-plant (*Mimosa pudica*) and see them shrink from us like frightened things? It is something of a surprise to us now to find other common plants, like *Cassia nictitans*, the partridge-pea, and sensitive joint-vetch behave in much the same manner. Species of Oxalidæ close quickly after being plucked. Some ferns will not wait to be brought home before they fold their pinnæ together. Successfully to press such plants they

must be laid between the pages of a magazine as soon as they are picked, and then, with stiff covers, they can be firmly bound with a strap and taken home.

Some plant leaves close when the sky is darkened by an approaching shower. These come under the category of sleeping leaves. Most leaves sleep—that is, assume a different position upon the stem at nightfall. Could we see the vegetable world at night, it would present many surprises. All of these sleeping movements seem to have one end in view—namely, the protection of the upper and more sensitive surface of the leaf, in order to prevent excessive radiation of moisture, and consequent injury from cold. Plants whose leaves are pinned down in their diurnal position will suffer severely in frosty nights, while those which are allowed to assume their sleeping position will take no injury. In the sleeping position the leaf usually presents its edge to the zenith, instead of its flat surface, twisting and turning its peduncle in order to accomplish this result. A pair of leaflets will shut together, folding the upper surfaces inward. In a species of acacia each leaflet of a pair



MIMOSA ASLEEP

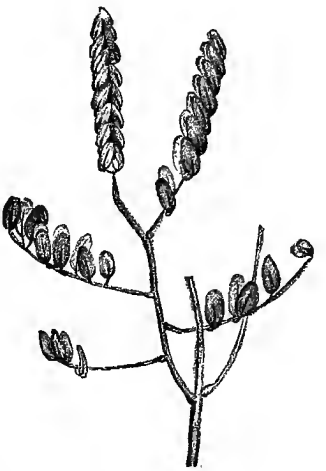
bends towards its mate, and all drop towards the apex, overlapping one another. The resemblance to leaves is thus quite lost, and the tree looks as if "hung with little dangling bits of string."

LOCUST BRANCH AWAKE

In clovers the two lateral leaflets fold towards each other, drooping slightly, and the middle leaflet turns backward and falls like a box-cover over the edges of the other two. The leaves of sweet-clover (*melilotus*) twist through an angle of 90 degrees, so that the edges of all three are turned towards the zenith, the upper surfaces of the two outside leaflets facing inward, one twisting to the right, the other to the left.

The pease, beans, lupines, desmodiums, and others of the pulse family present conspicuous examples of sleeping leaves. Most remarkable of all is the *Desmodium gyrans*, a native of India, found in greenhouses and known as the telegraph-plant. Each large leaflet is attended by two very small, perhaps interrupted, growths of leaves; for this species probably ranks midway be-

tween the one-leafed and three-leaved desmodiums. The large leaflet droops at night, and lies close to the stem. The small lateral leaflets are affected more by changes of temperature than by darkness. At a rather high temperature, say from 70° to 80° Fahr., they move up and down with little jerks. Sometimes several of these movements occur in a minute, and again they are slow. They seem to jump about for pure mischief and fun, since it cannot be perceived that any good is done to the plant by these movements.



LOCUST BRANCH ASLEEP

Instances of sleep movements of plants might be indefinitely multiplied, and the botanist—anybody, in fact—may visit by night the shrubs and small plants in his own vicinity with the keen enjoyment which attends the discovery of new truths. As morning dawns the sleeping leaves wake up—that is, resume their day position, reversing the twisting process of the evening before. Says Darwin, whose exhaustive experiments

have reduced the subject of plant movements to a science: "Excluding a few genera not seen by ourselves, about which we are in doubt, and excluding a few others, the leaflets of which rotate at night and do not rise or sink much, there are thirty-seven genera in which the leaves or leaflets rise, often moving at the same time towards the apex or towards the base of the leaf, and thirty-two genera in which they sink at night."

The cotyledons, as well as many flower petals, sleep at night. The purpose of the latter is, of course, to protect the stamens and pistils from frost.

The cause of the sleeping movements of leaves, as well as the nutation of all the plant's parts, is an alternate growth of opposite sides of the stem, preceded by a swelling of the cells, bending the leaf or leaflet away from the more turgid cells. In addition, highly sensitive leaves have a joint or cushion at their base, called a pulvinus. It consists of a mass of nearly colorless cells, somewhat convex in outline, whose growth has ceased. These cells become turgid more quickly upon one side than the other, causing a movement in the opposite direction. Two-thirds of the petiole of *Oxalis sensitiva*, and the whole of the short stems of the leaflets of the sensitive-plant, are converted into pulvini. Further than this the botanist cannot go. What makes the swelling of the cells? Is it certain properties or movements of protoplasm, or does the power lie in the cell walls? Whatever the answer may be, it is one of those things that "we know not now."

The movements of stamens and pistils have reference

LOCUST, MELILOT, LUPINE, OXALIS — ASLEEP

to their fertilization. The six stamens of the barberry lie curved under the arched petals. Touch them lightly with a needle-point and they spring suddenly towards the pistil, brushing it with their anthers. Some composite flowers possess sensitive stamens. In the chiccory the anthers are curved outward. A touch causes them to straighten and bring their pollen along the style of the pistil. In portulaca the stamens spring outward when touched.

Among the spontaneous movements of plants must be included the bursting of pods, already referred to, by which seeds are scattered in every direction.

The movements of insectivorous leaves have also been described. The movement of the sundew leaf when it closes over the hapless fly caught upon its gland-tipped bristles can be plainly seen. In cases like these the insects have a tardy revenge, in that the digestive powers of the leaf are soon exhausted. In the sundew, at least, after a few repetitions of the process, the bristles become rigid, the leaf turns yellow and dies, a warning example perhaps of the effect of high living.

Dr. Asa Gray closes a brief chapter on the movements of plants with these words: "That plants should execute movements in order to accomplish the ends of their existence is less surprising now, when it is known that the living substance of plants and animals is essentially the same; that the beings of both kingdoms partake of a common life, to which, as they rise in the scale, other and higher endowments are successively superadded."

## VII

## THE COMPOSITÆ

The Golden-rod for a National Flower—Characteristics of Composite Flowers — Disk Flowers — Ray Flowers — Tubulifloræ—Ligulifloræ—Dwarf Dandelions—Hawk-weeds—Thistles—Ragweeds, and other Composites

Among the candidates for our country's national flower is our American golden-rod. It certainly possesses many admirable characteristics. Beginning to bloom early in August, it defies autumn frosts and storms, and so is a type of those dauntless men and women whose courage and perseverance laid the foundations of our republic. It is a democratic flower. Not only the woods and meadows, but deserted ploughed-up ground, dry and dusty soil, spring into beauty with this covering of golden blossoms. It adorns the poor man's garden or the rich man's hedge. We are grateful to it for concealing so much that is arid and uninteresting.

There are forty-two species of golden-rod mentioned in Gray's Manual, divided into the Virgaurea, all whose heads of flowers are borne upon short stems, and the Euthamia, with sessile heads. There are but two of the latter, and they are easily distinguished by their flat corymbose heads and very narrow leaves. Around Sag Harbor, on the eastern end of Long Island, both species

of the Euthamia grow in great profusion, sometimes low and delicate, again tall and showy.

Not every one knows that there is a white golden-rod. The Solidago concolor is often taken for an aster. The cream-tinted flowers grow in clusters in the leaf-axils, along a simple, rarely branched stem. A yellow variety with rather larger heads grows in the same way. All the others have mostly terminal blossoms in long or short panicles, one-sided or twisted, contracted and stubby, or spread out into great yellow fans.

The sweet golden-rod (*Solidago odora*) gives out from its crushed leaves the scent of anise. I came across an unusually large plant of this species growing in a romantic spot at the head of Sterling Lake, well up among the hills in Rockland County, New York.

One of the tallest is the Solidago sempervirens, seven or eight feet high. Its blossoms are large and handsome, although the racemes are rather smaller than those of Nemoralis and Juncea.

The leaves of golden-rod present every variety. They have one or three strong nerves, are smooth or rough, entire or serrate, clustered thickly or scattered along the stem.

Side by side with these yellow beauties spring up the regal asters. The golden aster (*Chrysopsis*), found thickly in New Jersey pine-barrens, on Nantucket Island, and Cape Cod, is not a true aster. Neither is the pretty white-topped aster (*Seriocarpus*), growing in thickets and woods. The real aster is a perennial herb (except two species which are annuals) whose rays are white,

purple, or blue. The disk is deep yellow, sometimes purple. The flowers grow in corymbs, racemes, or panicles. An autumn drive up and down New England hills, where the road-sides are massed with the soft white and purple bloom of asters, touched with splashes of golden-rod, presents a picture not to be surpassed, even by the luxuriance of tropical growth. The driver is wearied with constant petitions to stop, and the wagon floor is piled high with gorgeous plunder, designed for home adornment. The purple asters, upon being gathered, should have their stems immediately covered with wet moss, else they will wilt beyond recovery.

Both of these queens of the autumn, together with many of our summer and a few of our spring flowers, belong to the great family of Compositæ. It is the largest of the families of flowering plants, and contains one-tenth of all the known species, one-eighth of which are indigenous to North America. If, therefore, the sentiment of the nation demands floral expression, it were fitting that the choice should be drawn from this family.

They are the compound flowers of early botanists, since it was long ago recognized that members of this family—the daisy, for example—were not simple flowers, like a hawthorn, with petals and sepals surrounding stamens and pistils. That which resembles the parts of a calyx is an involucre of bracts. What seem to be petals are rays. The central disk is a group of individual flowers (in the daisy some two to five hundred), each having its own tiny calyx, corolla, five stamens (rarely three or four), and pistil with divided stigma.

Separate one of the disk-florets of the daisy, and place it under a strong glass. The calyx is joined to the ovary, which contains a single, hard, dry seed, without albumen, called an achene. The calyx in our daisy is cut off abruptly just above the ovary, but in many of the Compositæ it is prolonged into various shapes. So we may know the cichory by its cup-shaped top; the sunflower by two rabbit-shaped ears; the sneeze-weed by five such ears, or scales; the ugly sow-thistle by a tuft of soft hairs, a true fairy dust-brush; a dandelion by the dust-brush lifted up on a long handle; the blazing-star by each bristle feathered. All such developments of the calyx-top are called pappus, and its determination greatly aids in assigning the plant to its proper genus.

PAPPUS OF DANDELION

Often a single bract grows outside of the calyx, called chaff.

The corolla in our daisy floret is tubular, with five points at the summit.

The stamens, five in number, are united by their anthers into a tube. They stand upon their filaments, and this ring is tipped with five sterile points. The anther-cells open inside, and discharge their pollen upon an unripe but growing pistil. As the pistil protrudes, it carries the pollen upward with it, till it is within reach of the visiting insect, which bears it to another ripe

pistil. The two halves of the stigma curve on opposite sides of the flower like two tiny hooks.

So much for the disk flowers, and they are borne upon a flattened receptacle. When the receptacle is laid bare, it may present a flat or conical surface, comparatively smooth or deeply honey-combed.

The marginal rays of the daisy are spread-out petals, each enclosing one pistil. They are called strap-shaped corollas, and in some flowers are neutral, with neither stamens nor pistils. The daisy, then, has both kinds of flowers, disk and ray, the latter fertile but imperfect. The Vernonia (iron-weed), a tall, handsome, bright purple flower, has no ray flowers, but heads of tubular corollas. These, and in all eighty genera out of the family—much the larger part — comprise the Tubulifloræ division, in which there are no strap-shaped corollas in the disk. The Ligulifloræ, or Cichory tribe, numbering sixteen genera, have no ray flowers and no tubular corollas, but strap-shaped corollas in all the flowers which are perfect. In these there is, of course, no centre or disk. The common dandelion and pretty blue cichory will be recognized as belonging to this division. There is a third division, Labiatifloræ, in which the corollas are two-lipped, like mints. But, besides a few species found in New Mexico, Arizona, and Texas, most of them grow in South America.

RECEPTACLE OF DANDELION

The leaves of Compositæ agree only in one respect: they are without stipules. The stems are often hollow, and are filled with watery, or milky, or resinous juice.

Among the Ligulifloræ, a small cousin of the dandelion, is the dwarf dandelion (*Krigia*). It hangs, the daintiest of tassels, from delicate stems, with root-leaves finely cut. One may find this plant in the cleft of some tall rock, hobnobbing with the purple stems of that hair-like fern, Asplenium trichomanes, under the drip of wet mosses, and near a small bitter cress.

The hawk-weeds (*Hieracium*) belong to this division. Many of these are coarse and showy plants. One of them, the rattlesnake-weed (*H. venosum*), has leaves colored underneath with a beautiful rose-purple, the purple veins showing through on the upper surface. The flowers are yellow, in a loose corymb, and stem and midrib are hairy.

A tall road-side weed is wild-lettuce (*Latuca Canadensis*). It is, perhaps, nine feet high, with pale yellow heads of flowers in panicles.

The thistles and burdocks belong to the Tubulifloræ. There is a yellow thistle found along the coast, with yellowish prickles upon the leaves. The least bristling and the tallest thistle is Cnicus altissimus, ten feet high. The pasture thistle is occasionally found white. The Canada thistle, along with the common white-weed daisy and the cone flower (*Rudbeckia hirta*), are special plagues to the farmer. They are the most impudent and pertinacious of weeds, excepting, perhaps, the ubiquitous wild-carrot, and only the most untiring vigilance

will prevent them from maintaining complete ascendency over the soil.

There are about twenty species of wild-sunflowers, easily known by the two-eared pappus. They are branching herbs with wide rays, and are often mistaken for yellow daisies.

One of the prettiest spring flowers is Robin's plantain. The stems are hairy, the rays are fine, numerous, of a light heliotrope color. The place where I have seen it very abundant, set off by tall buttercups, is in a large old-fashioned apple orchard.

The plantain-leaved everlasting (*Antennaria plantaginifolia*) is one of our earliest spring flowers. The leaves and stem are cottony, and the involucre is white. Stamens and pistils are borne on different plants, an exception (though not the only one) to the rule of Compositæ. With antennaria, saxifrages, cinque-foil, columbine, and wild-strawberry blossoms, many a bit of pasture-land and top of a flat rock are converted into veritable gardens.

The miserable rag-weeds are grouped in the genus called Ambrosia. A fitter name would be one which a little girl called them (a child who saw with poetical feeling common things): "Candelabra; because," she said, "they hold their little green candles so straight." The sterile and fertile flowers of rag-weeds grow in different heads upon the same plant, the fertile almost hidden at the bases of the long spikes of greenish, sterile flowers.

Thoroughworts are an important branch of the Com-

positæ. Most conspicuous of these is the Joe-Pye-weed, which towers twelve feet in its loftiest moods. It bathes low, swampy meadows in a rich purple, flowering with blue and white vervain and the dark-hued Vernonia late in summer. The white boneset, dear to our grandmothers for its mild, uninebriating tea, may be known by its opposite leaves uniting around the stem. Hence its name—Eupatorium perfoliatum.

The blue mist flower of New Jersey is a lovely member of this genus. More common, one of the prettiest dwellers in our woods is the white snakeroot (*E. ageratoides*). It displays clear, white, close corymbs of flowers and fanciful leaves, thin and dark green, long petioled, very deeply and sharply serrate. I have a pleasant recollection of a "green and white luncheon" given in a cottage overlooking a picturesque lake, in which the white snakeroot formed the only floral decoration. Upon the table it was massed in a large centre, and bouquets of it, tied with white and green ribbons, lay at each plate. Large bowls, filled with the same flower, were in the room, and vases in the windows.

For floral decorations in August, what could be more effective than climbing hemp-weed (*Mikania scandens*), the only climbing Composite? It can be pulled in two or three yard lengths. Its clusters of pinkish blossoms, nestled among heart-shaped leaves, make it a striking and elegant vine. It may be found beside streams, twining among bushes, in full bloom in August.

## VIII

## PARASITIC PLANTS

The Woods in Autumn Full of Interest, Because Every Plant is Fruiting—Cancer-root, or Beech-drops—Indian-pipe—Color of Leaves and Stems of Parasites—Mistletoe—Cuscuta—Root-parasitic Plants—Monocotyledons Non-parasitic

THE leafy month of June may claim the rarest day of all the year, but for gorgeous, sensuous beauty the bright days of autumn stand without a rival. The autumn sunshine is glorious and not too dazzling. One may walk in the woods without fear of mosquitoes. The wind, instead of burning, cools the forehead, while the eye is simply bewildered by the brilliant coloring of the foliage. The undergrowth is aflame, and the branches of oak and maple are crimsoning. The scarlet stem and leaflets of the Virginia-creeper mingle with the wild-vine. Even the venomous sumach is seductive in red and yellow beauty, and paints the swamps with masses of rich color.

To the botanist in his walks there is a peculiar interest in the fact that the vegetable world is fruiting. Every plant now proudly displays that for which it spread its showy petals in spring, and wafted its fragrance to the passing insect in summer. Wild-rose hips nod to the scarlet berries of the Solomon's-seal and the gay fruit of Indian-turnip. Red and purple

berries and ripened pods play at hide-and-seek behind tall fronds of fern, great fans of golden-rod, and masses of white and purple asters.

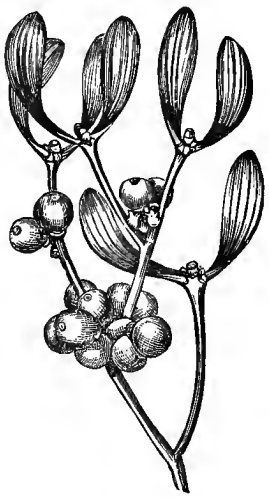
It was on such an afternoon in the waning September, on a hill-side among the chestnut-trees, that I first found the parasitic singular plant called cancer-root, or beech-drops (*Epiphagus virginiana*). They grow, the tallest, about a foot high, bear scales in place of leaves, are purplish in color, and have two kinds of blossoms. Those higher up with tubular corollas are the larger, and are sterile. Below are the less showy, fertile blossoms, with minute petals, which the ripening pod pushes off. The lack of green in stem and leaves at once betrays the unworthy secret of this plant. It lives, not on earth, air, and water, so freely offered, but on food manufactured by another. It is a vegetable thief, a parasite. By any code of morals, it is either lazy or vicious. It thrusts its roots into those of beech or chestnut trees, sucks their juices, and leads an unnatural, it would seem an unwholesome, existence. It flowers and fruits like other plants. The beech-drops belong to the broom-rape family, all whose members are root-parasitic, and destitute of green foliage. The one-flowered cancer-root is perhaps a more familiar species, growing in small clumps everywhere. Its stem is underground, and from that a low, naked scape arises, bearing a tubular, five-divided corolla. The stem and flower are brown, and the corolla is fringed inside with a yellowish beard. Another broom-rape is the squaw-root (*Conopholis Americana*), found among fallen oak

leaves. It is a thick, scaly stem, half a foot high, with a cone-like flower, yellowish or brown. The botanical name denotes cone-scales. This family contains 150 species, all parasitic on roots of trees and shrubs. One grows on roots of the furze, two feet high. Another is destructive to hemp and tobacco.

In the woods, and not far from the beech-drops, a bunch of Indian-pipe or corpse-plant grew. In the botany it is a monotropa, meaning turned to one side, a name taken from the bending of the flower at the summit of the stem. It is not a pleasant thing either to look at or handle, and it quickly turns black after being plucked. It is suggestive of life in death, as almost no other flowering plant, and that it should blossom and bear seed at all seems anomalous. It is, in fact, only at first parasitic, afterwards saprophytic, subsisting on decomposing vegetable mould. There are ten known species of monotropa found in our own and more northern latitudes. The pine-sap (*hypopithys*) is the only other mentioned in Gray's Manual. The name pine-sap may indicate its resinous fragrance, or its habitat, the pine woods.

The lack of green color and of leaves proper in these and similar plants indicates that they obtain their food already assimilated by other plants. They have, therefore, no need of chlorophyl or digestive organs of their own. The scales are abortive leaves, and do not perform the office of true leaves. Some parasitic plants are green, and they assimilate part of their food. Such a family is the Loranthaceæ, to which mis-

tletoes belong. They may be in the first instance planted in the soil. As their stems grow they throw out rootlets which cling to some tree, penetrate its bark, enter its vascular tissues, and become as firmly attached as if they were scions of the host. Fruit and forest trees — apple, pear, elm, maple, etc. — are attacked by the mistletoes. The Lombardy poplar alone seems to be exempt. The mistletoe so largely sold at Christmas-time in England is supplied principally from the apple-orchards of Normandy. The species is an evergreen-bush, thickly covered with light green spatulate leaves in pairs upon the stem. The clustered yellow flowers come out in February or March, and the whitish fruit ripens late the next autumn. The berries are filled with a viscid pulp, from which bird-lime is derived. By a curious sort of fatality, birds are the propagators of the seed. They eat the berries and wipe their sticky bills upon the branches of trees, leaving a seed or two to germinate in the bark. The mistletoe matures slowly, seldom dying till the host plant dies. It



MISTLETOE—(Viscum Album)

does not greatly interfere with the prosperity of the trees which it attacks. Should a branch upon which it has fastened decay, it will throw out adventitious shoots to some other part of the tree, and renew its hold. The mistletoe growing upon the oak was esteemed sacred by the ancient Druids, who cut off a branch with a golden hook, and dropped it into a white sheet held by a priest dressed in white. Prayers were offered to God for prosperity, after which two white bulls were sacrificed under the mistletoe. In Anglo-Saxon mistletoe is *misteltan*. The first syllable may have reference to the fog of the late autumn, when the berries are ripe, and *tan* means twig. There is an American species found in New Jersey and south, with larger and thicker leaves. It is the phoradendron. Still another, very slender and brown or yellowish, creeps over cone-bearing trees. Its name, arcenthobium, means "life of the juniper."

A very common plant may be found climbing around low shrubbery called gold-thread or golden-hair. It is the wholly parasitic dodder (*Cuscuta*), a sub-order of the convolvulus family, and thus akin to the morning-glory and sweet-potato. The vicious character of this plant is evident from its infancy. Instead of cotyledons, the seed is a coiled thread wrapped in albumen. It is dropped into the soil, and lifts its head above, like the first leaves of any other plant. It is then innocent enough looking, even when it bends towards its neighbor, nodding as if in friendly greeting. Once let it join hands, its grasp cannot be shaken off.

Greedy suckers will spring from the golden stem, bury themselves deep in the tissues of the host, and draw into themselves the sap, the life-blood, which is by right another's. Then the part near the soil dies, and is thrown off. The dodder inflicts double injury upon its host—often, in fact, causing its death—by twining tightly about its stems, crushing its tender bark, and interfering with the proper development of leaves. I have seen blackberry-bushes, the jewel-weed, alders, golden-rods, meadow-sweets, almost anything and everything, wrapped in a wild tangle of dodder. Through the glass the yellow stems, fat and greasy, look like caterpillars, and the suckers easily resemble the feet. One species is very injurious to flax, and another destroys clover-fields. One twists its stems into ropes, and bears flowers encircled with curly bracts.

The sucker-like roots of parasitic plants are called haustoria. They are clusters of hair-like roots, devoid of root-caps, thickened at their ends. It is by means of such haustoria that the poison-ivy clings to its supports.

A large order, containing twenty-four species, mostly tropical, is the Cytinaceæ. A scaly stem bears a single sessile flower, or, as in the case of *Rafflesia Arnoldi*, a single flower seems to burst from the bark of the host plant. This giant flower is found in Sumatra, on a species of Vitis. First a knob is seen, which grows and opens like a head of cabbage. When fully grown, it often measures nine feet around, and weighs fifteen pounds. After a few days a strong putrid smell is emitted, which

attracts insects, to assist in its fertilization. Scarcely a desirable specimen, one would think, for a herbarium!

Many beautiful plants are root-parasitic, which give no external evidence of such a character. Thus, the handsome foxgloves and gay purple gerardias are more or less parasitic on roots of small shrubs. Does this fact explain why foxgloves, flowers and all, turn black when dried? Certainly a concealed parasitism is less repulsive than the open display which the cuscuta makes. There is no more beautiful flower than the slender gerardia, dotting the fields with its purple bells, or the seaside-gerardias, as I found them near the eastern end of Long Island, growing in masses of rose color.

There are other genera of the figwort family which are suspected of being parasitic. Haustoria are often found upon the roots of melampyrum and pedicularis. The melampyrum, or cow-wheat, frequents all our woods. It is a stiff plant, branched and leafy, the upper leaves toothed at the base, those nearest the flower scarcely distinguishable from the greenish, yellowish corolla.

Pedicularis, the wood-betony, is often mistaken for a mint. It bears a spike of yellow and purple flowers, and its leaves are deeply and irregularly cut.

The eyebright (*Euphrasia*), parasitic on roots of grasses, and the yellow-rattle (*Rhinanthus*), are less known. Both are Alpine flowers, found in northern New Hampshire and along the shores of Lake Superior. All attempts to cultivate such plants will fail unless artificial food be provided.

All the parasites, except a few algæ and the fungi, are either monopetalous or apetalous, and belong to the dicotyledonous division. All monocotyledons seem to be non-parasitic. Many parasites grow indifferently on one or another host, while some are confined to but one tree or shrub.

The parasitic and hurtful nature of many fungi is well known. The near approach of the practical science of medicine to that of botany has been emphasized by the coming of Asiatic cholera to our very door. The words "bacilli" and "bacteria" have a familiar sound. While it does seem as if the vegetable and animal world could dispense with hurtful parasites and be none the worse off, yet we are not quite ready to set aside the utilitarian theory and declare that they have no use. At any rate, they form an interesting subject of study, whose pursuit may well become one of the recreations of the botanist. A few facts about fungi will be given in a separate chapter.

## IX

## AQUATIC PLANTS

The "Trout-ponds" — Eriocaulon Septangulare — A Wet-meadow Bouquet—Buttercups, Cardinal Flower, and Other Plants Growing in Wet Places—Finding a New Species

By making a slight detour on the road from Bridgehampton to Sag Harbor, one may leave the sandy road, and find shade, coolness, and a hospitable welcome at the "Trout-ponds." The owner of this place and his wife have taken advantage of the natural beauty of the spot, and touched it up with wild-flowers, moss, stumps, stones, rustic bridges, climbing plants, baskets of trailing vines, ferns, shrubs, and great trees. Most of the trees and the water were originally there, but the work of adornment has been done *con amore* and with taste.

It was here that I noticed unfamiliar white dots on the surface of one of the ponds. They looked like diminutive onion-blossoms. The local name was water-daisy, but in the Manual they are known only as pipeworts. My species had a seven-angled flower-scape, and bore the name of *Eriocaulon septangulare.* The family of pipeworts belongs mostly to the tropics, but is represented here by three genera. They grow, all but one or two species, in water, side by side with graceful confervæ. The roots are fibrous, easily pulled

out of the soft mud. The leaves are radical, linear, composed of soft cells whose walls can be seen with the unaided eye. The small flowers are collected in close heads with woolly bracts. The central flowers contain stamens, the outer, pistils, and together they form a tight little button, one-tenth of an inch in diameter. They cannot bloom under water, and consequently will stretch their necks, six feet if necessary, to reach the surface. They are curious and interesting little plants, well worthy of our attention, as are most aquatics. The borders of running streams, or ponds of still water, or swampy meadows, are the botanist's hunting-grounds. Here is a bouquet which I have gathered in one wet meadow in mid-summer, and which, for variety and delicacy, cannot be rivalled: blue forget-me-nots, yellow and white buttercups, water-cress, the marsh-pennywort, northern starwort, seed-box, swamp-loosestrife, marsh-bellflower, water-avens, pimpernel, bugle-weed, galium, scutellaria, marsh-speedwell; while farther up, on drier ground, the field was radiant with Turk's-cap and yellow (*Canadense*) lilies, and sundrops (*Œnothera fruticosa*). The small aquatics are retiring flowers, and love to hide behind moss-clumps and tall weeds, and they need coaxing to show themselves. The plants of dark, dank swamps are larger, and grow more boldly, since they have less to fear, their surroundings being their protection.

The true forget-me-not (*Myosotis palustris*) is disappointing in our country, because it is in such a hurry to drop its yellow-eyed blue petals and form fruit.

Consequently, only a few topmost blossoms are found on a long panicle of pods. The European species is larger and more leisurely, and is the flower, probably, which has inspired poetic fervor.

Many buttercups are aquatics. The name of the whole family is *Ranunculus*, the Latin for little frog, and was applied by Pliny. The common water-crowfoot is white and small. Its leaves grow under water, their finely-cut divisions floating like sea-weeds, and, like them, collapsing when taken out. Such leaves are found on many aquatics, and they present a larger surface to the water than undivided leaves. A rarer species is the stiff water-crowfoot, the leaves of which retain their form out of water. The largest is the yellow water-crowfoot, whose petals are equal in size to those of our common land species, the bulbosus. One of the prettiest is the creeping spearwort, which sends out roots from the joints of its thread-like stems. The leaves of the seaside-crowfoot are heart-shaped, and it throws out runners for the propagation of new plants.

Nearly all of our indigenous buttercups prefer wet soil. The common terrestrial species are immigrants from Europe, and on account of their acrid, blistering juices are not liked by cattle. They are therefore passed by, and left to ripen seed. This immunity from one of the commonest means of destruction enables them to gain ground rapidly in their adopted country, and they are becoming a noxious weed. When cut with hay and dried the harmful character of the leaves and stems disappears.

One of the prettiest of leaves belongs to the marsh-pennywort (*Hydrocotyle*). It is crenately-lobed, kidney-shaped, thin, and glossy. Some call it water-ivy. The blossoms, clustered in the leaf-axils, are minute, and, moreover, they belong to that exasperating family of Parsleys which must be studied with a strong microscope, since it is by the fruit (two small dry carpels in each flower) that the species is determined. There are other aquatics besides the pennywort in this family, some, as the water-parsnips, very poisonous. The poison-hemlock (*Conium*) furnished the fatal cup which Socrates was condemned to drink.

The marsh St. Johnswort is one of the prettiest of the family, and the only one which bears pink blossoms. All the rest are yellow. They may be known, besides, by their dark or light dotted leaves and red pods. The rural farmer says that a white-nosed horse cannot eat the common St. Johnswort without having a sore nose, but that a horse with a nose of any other color is not unpleasantly affected!

The water-avens is a near relative of the strawberry. Its flowers have several feathered, hooked, and jointed pistils, whose styles remain attached to the seeds when ripe, and float them in the wind far from the parent plant.

In the purple water-avens the calyx and corolla are purple. It is a plant stiff and rather tall, two feet high. The lower leaves are much divided, those on the stem three-lobed. The flowers nod, but straighten in fruit.

The marsh-bellflower (*Campanula asparinoides*) and galium (*G. trifidum*) each have weak stems with hooks turning backward, making a rough stem. They are not quite so savage as the arrow-leaved tear-thumb, a buckwheat (*Polygonum sagittatum*) whose stem-angles are veritable saws, and leave a painful scratch on the careless hand which gathers it. The bellflower is white, exceedingly delicate, scattered here and there on the slender stems, much like the blue harebell of the mountains. The galium has leaves in whorls of four or six, with a small white corolla of three or four petals.

Two of our wet-meadow bouquet are mints — the bugle-weed and scutellaria, or skull-cap. The fruit of the Mint family is four naked nutlets, which can be seen lying snugly in their calyx bed, with the style of the pistil standing in the centre. This fruit, in the skull-cap, is covered by a curious calyx, the upper lid of which is shaped like a hood with a raised crown, and which shuts down on the lower lip. It will open like the corolla of a snap-dragon if pressed in from the sides. Two species (*S. lateriflora* and *S. galericulata*), the latter with much the larger flowers, belong to our wet-place bouquet. The flowers are blue.

Why is it that the cardinal-flower has not crept into poetry? If Burns could wax eloquent over that "wee, modest, crimson-tipped flower," the mountain-daisy, one would suppose some lover of flowers would immortalize in song this regal creature of the river-banks, the cardinal-flower. It is not chary of its flowers, but

blooms a whole great panicle all at once, with such rich red velvety petals they are almost dazzling to look into. The cardinal-flower is a Lobelia, and, like all of its family, has an irregular, monopetalous corolla, split down upon the upper side. The pistil protrudes through this split, and is rubbed against by the pollen-laden insect coming from another flower. Near by, perhaps, is its cousin, the great blue lobelia, three or four feet high. It is a coarser and more plebeian plant, not so neatly and compactly built, but is showy, with corollas one inch long.

A dull green plant may often be seen growing on loose stones in shallow running water. It may be taken for a sea-weed, with its forked leaves sheathing the stem. It is the river-weed, the only representative of its family in our country.

The arrow-shaped leaf seems to be a favorite with some aquatics. There are two very common plants with such leaves: the blue pickerel-weed and the Sagittaria. The first is a showy flower of ephemeral duration. The anthers are blue. The ovary contains three cells, two of which are empty; in the third a single hanging ovule grows. Sagittaria is not particular as to the quality of the water which it inhabits. I have seen it growing luxuriantly beside the railroad, in stagnant pools which were originally made by digging out the sides and throwing the dirt into the middle to elevate the track. Some of the species are destitute of true leaf-blades, possessing only expanded petioles called phyllodia. Such apparent leaf-blades stand with

their edges instead of their flat surfaces looking upward and downward.

The water-plantain (*Alisma plantago*) has broad root-leaves with prominent ribs, like the common plantain. The small white flowers are borne in loose panicles upon branches whorled around the stem. In fruit the many ovaries are arranged in a ring upon a flattened receptacle, much like the Mallow family.

Speaking of mallows, we must not omit a mention of that showy flower which in August turns the salt-marshes around Newark into gardens of rosy bloom. It is the *Hibiscus Moscheutos*, beautiful for its size, rich color, and free bloom. Confectionery is made from the mucilaginous roots of marsh-mallow (*Althæa officinalis*), a perennial also inhabiting salt or brackish marshes.

Sweet-flag, arum, and skunk-cabbage belong to the Arum family. If one should hunt for the large coarse leaves of the skunk-cabbage late in fall, he would be puzzled to find no trace of them. Instead there would be an ugly, foul-smelling oval mass of seeds, as large as a lemon, enclosed in the fleshy spadix, whose coat is black and rough. This evil-looking fruit is attached to a thick curved stem, and near by is the beginning of next year's leaf. When first I saw this black mass, and until I had pulled it apart with a pair of sticks, I thought I had discovered a new and wicked fungus.

Bur-reeds and cat-tails are so common as to need no description. The ordinary cat-tails, which form a large part of the luggage of home-returning city board-

ers have flat and broad leaves. A smaller and rarer species produces narrow leaves, and a looser spike of hairy fruit.

The Pond-weed is a rather large family, of which the common eel-grass which grows in salt-water bays is a member. To find the flowers of eel-grass, you must pull off one of the long grass-like leaves from the stem, which it sheathes. There, growing on one side of a linear spadix, are the pistils and stamens, without perianth, and sessile, in alternate rows.

Like this, in the fact that all floral envelopes are wanting, is the lizard's-tail, a marsh perennial. Its stamens and pistils are white, and make a pretty, long, nodding spike, over which shake the protruding hairy filaments of the pistils.

The Iris family, with its equitant leaves, is better represented by cultivated than wild flowers. Crocuses and gladioli belong here; also the blue, yellow, and white flower-de-luces. The wild-iris, with its pretty light-blue flowers, is deservedly a favorite. There are six species, two of which are common about New York. They are the larger blue-flag (*I. versicolor*), and the slender blue-flag (*I. Virginica*). The leaves of the latter are scarcely wider than grass leaves.

A very striking and pretty member of this family is the Pardanthus, a Chinese importation. I have found it on road-sides wet with springs. The name means leopard-flower, suggested by the red and yellow lily-like perianth, mottled with purple spots. From the resemblance of the fruit—numerous black seeds cover-

ing a central column—to a blackberry, the common name is blackberry-lily.

Among sea-side plants the marsh-rosemary is a favorite for winter vases. It bears lavender-colored blossoms, loosely spiked on one side of bushy woody-stemmed branches. The corolla remains, brown and scarious, after the plant is plucked and dried.

This chapter shall end, as it began, with reference to the flora of eastern Long Island. I was spending a vacation there, when a friend told me of a lovely pink flower (sometimes white) found in one locality only. "I don't tell everybody about it," said my friend; "people would soon pull it in such quantities as to exterminate it. It is low, something like the old-fashioned moss-pink. For ten years I have been here, and seen it only in that one field, which it covers like a carpet."

An afternoon was set aside for a ride to this place. Past quaint old windmills and graveyards, along the almost historic road to Southampton we drove, with the sight and sound of the sea ever growing nearer. At length we turned from the main road and took a lonely way, crossing one of the arms of the ocean, stopping behind a sand-dune which hid the view but not the grand sound of the surf. There was the field, pink with low-growing dainty blossoms. It might have been an acre, covered so thickly we could scarcely walk without stepping on them. The flower was a Sabbatia, like, and yet unlike, the taller one common on the New Jersey coast. The latter, perhaps twenty inches tall, is

a slenderer annual with more branching stems. The Long Island species, the tallest of which reached five inches, had thick stems. The centre of the pink corolla was yellow, and the blossom, spread flat open on the end of its stalk, had a peculiar frank and confiding look. Some flowers, like people, look you full in the face. My friend's flower is probably a variety of either *Sabbatia gracilis* or *S. stellaris* (two nearly-related species) of the Gentian family. It almost deserves recognition as a separate species. We went home with the virtuous feeling that we were possible discoverers, a satisfaction that could hardly have been more unalloyed had we stumbled across a gold-mine.

## X

## THE CONE-BEARERS

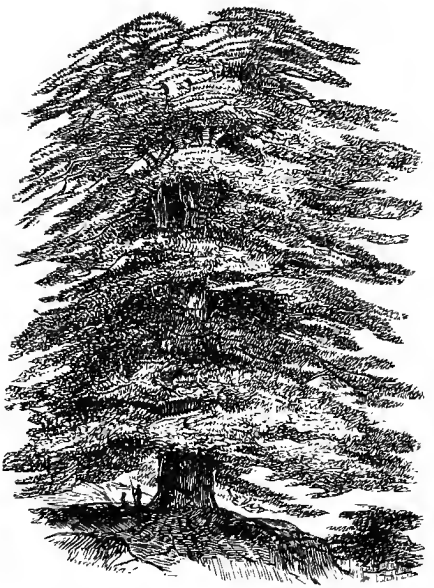
The Forest of White-pine—Cedars of Lebanon—Cones—Naked Seeds—"Big Trees" of California—Pines—The Gingko

Few spots on earth are more attractive than forests of white-pine. Before the lumber-pirate, with his keen scent for pine planks, had discovered the spot, a grove of these majestic trees stood on the bank of a picturesque lake in my early Connecticut home. I have spent many hours there comforted and delighted. Glimpses of the lake shone through the trees. These rose tall and straight, their trunks nearly branchless below, weaving their top branches together so that the sunlight was almost forbidden to enter. Some stray beams did fall upon a noisy brook that was always hurrying to reach the lake. It was a lonely place. The sounds were those of far-away birds, the brook, and the stir of the pine-needles. Is it because the needles are so many tiny strings, and the pine grove is an orchestra of harps, that the wind playing on them produces a sound so different from the sighing of beech or oak or maple leaves? The music of the pines is the most exquisitely tuneful and mournful which the varied voices of nature express.

Near the brook grew the large leaves of wild-turnip and skunk-cabbage. Jack-in-the-pulpits shook their saucy heads, and here and there, elegant and stately, stood the "stemless" pink lady's-slipper. A further search revealed in shy corners the small yellow lady's-slipper, an orchid not so rare, but which, as it happens, I have found nowhere else. The "Hartford fern," with its fringed ends of fruit, ran rank over the place, and dark blue violets nestled in its twinings. The yellow fallen pine-needles lay inches deep, making a soft carpet which the finest hotel parlors might covet.

It was always clean in my grove. The low shrubbery, brambles, and such things, which litter the common woods, were cleaned out, one might fancy, by fairy house-keepers. Little spiders and ants were indeed busy around the trunks of the trees, but except the ferns and small green leaves shining through the golden needles, there was no plebeian growth, nothing to soil your dress as you sat, or lay full length upon the ground. And then the smell! It was resinous, spicy, sweet. The royal poet of Israel likened the smell of the garments of his beloved to "the smell of Lebanon." Was it not a delicate compliment? The fragrance suggested was from those cousins of the pines, the mighty "cedars of Lebanon," some of which are still standing. One grove, distinctively called "Solomon's grove," numbers about four hundred trees, several of which may date from that king's time. The most of them are of more recent growth. The missionary Rev. Henry H. Jessup found by actual exploration "eleven distinct

groves of cedar on Mount Lebanon, two of them of great size, and numbering thousands of trees." The trunk of this cedar rises sometimes many feet without



CEDAR OF LEBANON

branches, and then sends out long, crooked, horizontal branches, thickly leaved at the ends. The cone is smooth and tapering.

The pines and their allies form a sub-class of the apetalous division of flowering plants. The flowers

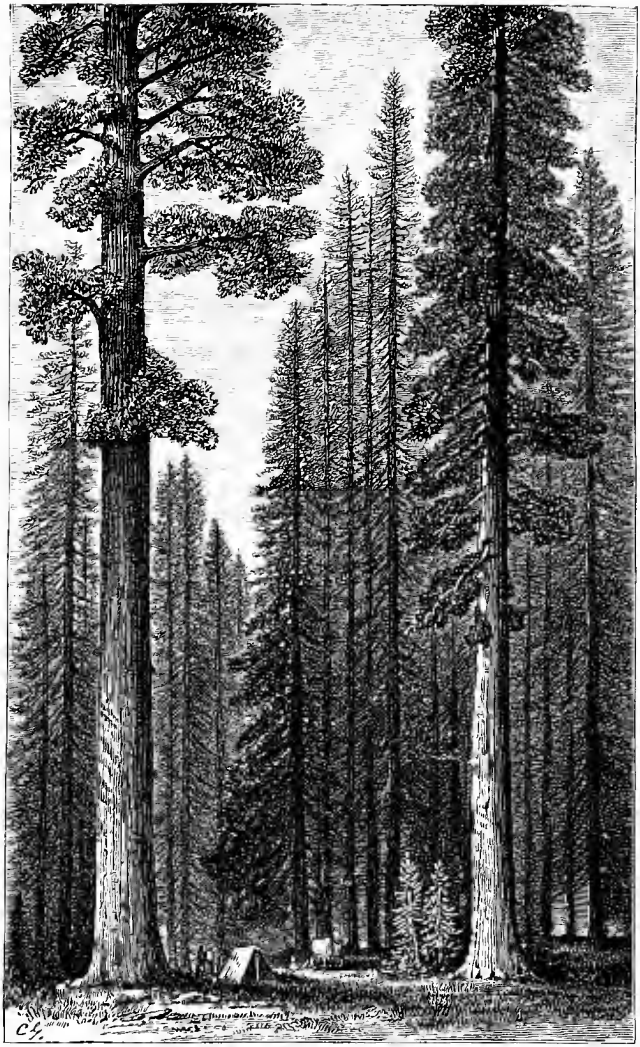
bear little resemblance to ordinary flowers, being composed of two sorts of catkins, one bearing stamens, the other not pistils or closed ovaries, but naked seeds protected by scales. These scales, at first soft, then hard, are the cones. Because the seeds are naked, and the pollen falls directly upon them from slits in the anthers without the medium of style and stigma, this class of plants is called in botanical language Gymnospermæ—naked-seeded. The scales of the cones are spirally imbricated, like shingles on a roof, around the central

CEDAR-CONES

axis. Each scale bears one or two seeds on the inside near its base. The catkins of stamens grow around bases of newly forming branches just above the cones. When the anthers are ruptured, the wind blows the abundant pollen everywhere through the forest, part of it falling upon the cones just below. As soon as the seeds are fertilized, the protecting scales close upon each other. When ripe the scales fall away, and the seeds, with part of the scale-lining attached as a wing, are torn off and blown away by the wind. This is really a very simple process, and would indicate that the cone-bearers are lower in rank than the flowering plants, which produce more complicated stamens and pistils. This is true, and large areas of pines and firs covered the earth before the advent of a violet or primrose.

Our familiar species include many pines (yellow, scrub, pitch, etc.), spruces, firs, hemlocks, balsams, larches, arbor-vitæ, and cypresses. The junipers and yews are not true cone-bearers. The former bear what resemble blue berries, and the latter red. A tiny excrescence first appears upon the end of a stem. It is the naked ovule, and after it has been fertilized a small disk is produced at its base (really a coalescence of scales), gradually thickening, growing upward and enveloping the seed. At length this envelope closes quite over the seed, as the fleshy part of a cherry surrounds the pit.

The cones of true cone-bearers vary greatly in size and prettiness. That of the pitch-pine is coarse, each scale tipped with a repellent bristle, as becomes the



GROUP OF SEQUOIAS, OF ALL AGES

fruit of so gaunt and grim a tree. The spruce-hemlock bears tiny cones, hanging like bells on the ends of its branches.

The sequoias, the largest trees known, singularly enough, bear cones as small as apples, and round in shape. There are more than twenty groves of these California "big trees," those of the Mariposa and Yosemite regions being the most famous. The largest, called "the prostrate monarch," fell probably 150 years ago, and is 400 feet long, with a trunk diameter, including the bark, of 40 feet. These trees are too well known to need description.

Next in size to the sequoias are the sugar or giant pines of California. They rise to a height of 200 feet, with a thickness of 20 or 30 feet in the trunk. The cones are 18 inches long and four in diameter. Indians eat the seeds pounded and baked.

Along the Pacific coast, high up on the Sierras, grow the red-cedars to an enormous height. Seeds from the cones of all these California trees are being planted in the Eastern States, in our city parks, and in England, where there is now a craze for cone-bearing trees. It will be interesting to note the result.

Our most important as well as most beautiful species is the white-pine. The slender leaves grow five in a cluster. Those of other pines are in pairs or threes. The needles of the white-pine are a bluish-green in color. The trunks, smooth for pines, rise without branches from 120 to 160 feet in height. But, alas! the beautiful straight planks, almost free from resin,

which these trunks afford, tempt the commercial axe, and our country is fast being denuded of its famous pines.

The finest pine of the Southern States is the Georgia pine, also a tree of large growth. It is much sought after for flooring and ship-building.

The trunks of all these trees are more or less resinous. Tar, turpentine, and similar products are obtained from them. The process is ruinous to the tree, which, when it ceases to produce resin, is cut down for timber. Pieces of bark are torn down the trunk, and a groove or trough is cut across the wound, into which the gum flows.

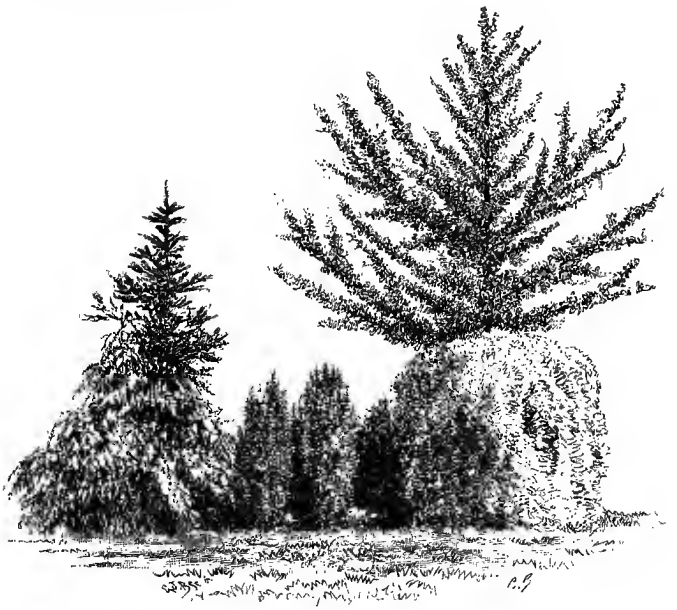
Since many pines love sandy soils, they are useful in holding together drift-sands. The *Pinus pinaster* has been largely planted on the Bay of Biscay in order that its far-reaching, interlacing roots may hold the sand dunes in place. Its peculiar shape also, the branches curving upward, enables it to withstand the sea gales.

Many species take kindly to transplanting, and we are familiar in our parks with European and Australian evergreens. Norway spruces and pines are favorites. The gingko is so singular a tree, with its broad, leathery, striated leaves, it would seem to belong anywhere but among the gymnosperms. Its seed is, however, naked, developed terminally upon small peduncles, like the yews, among which it is classified.

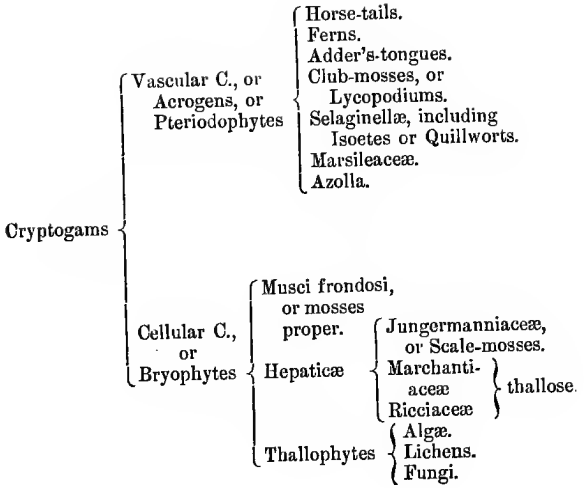
Nearly all are evergreens, and form a beautiful dark shading to the forests in any season. In spring, when the young branchlets appear on the tips of the dark

green boughs, no trees can boast of more beauty than the hemlocks, spruces, firs, and cedars.

Travellers who have visited famous gardens in Europe recall with pleasure how, by cutting and training, this class of trees is made to assume fantastic shapes of towers, arches, bridges, statues, ruined castles, etc. The possibilities of evergreens in this direction are beginning to be understood by Americans, many of whom are learning how to cultivate beauty at home as well as seek for it abroad.



FIR HEMLOCK IRISH YEWS GINGKO


Cryptogams
Vascular C., or Acrogens, or Pteriodophytes
Horse-tails.
Ferns.
Adder's-tongues.
Club-mosses, or Lycopodiums.
Selaginellæ, including Isoetes or Quillworts.
Marsileaceæ.
Azolla.
Cellular C., or Bryophytes
Musci frondosi, or mosses proper.
Hepaticæ
Jungermanniaceæ, or Scale-mosses.
Marchantiaceæ
Ricciaceæ
thallose.
Thallophytes
Algæ.
Lichens.
Fungi.

## XI

## FLOWERLESS PLANTS

They Grow Everywhere—Meaning of Cryptogam—Cellular Arrangement—Difference Between Lower Orders of Animal and Vegetable Kingdoms—Harmful Plants—Vascular Cryptogams—Horse-tails and their Allies

THE plants which bear no true flowers form the largest and in some respects the most interesting part of the vegetable kingdom. To the lover of the microscope they afford an unfailing pleasure. They grow everywhere, in city and country, in wet and dry places, in the hottest and the coldest climates, and possess this advantage over our garden plants, that many of them can be studied in winter. First in order of existence, they prepared the way, by making moulds and soil, for higher orders of plants to grow. They also made the present life of man possible by creating great beds of peat and coal for his use. Even now, when the vast forest trees of the coal measures have dwindled to rush-like and trailing representatives, this lowly order of plants is useful. They cover bare rocks with verdure. No place is so bleak, so exposed, so visited with storms and tempests that a moss or lichen cannot grow there. Within a thousand feet of the snow-line, on the fearful peaks of the Himalayas and Andes, where no foot of man ever has been or ever will tread, where it is ever lonely,

save as the wild condor or eagle looks upon it; even there some of these humble plants grow, cause rocks to crumble, form soil, and do their assigned part in the vast economy of nature. By the interlacing of their numerous roots they form a spongy soil which retains moisture and prevents inundations.

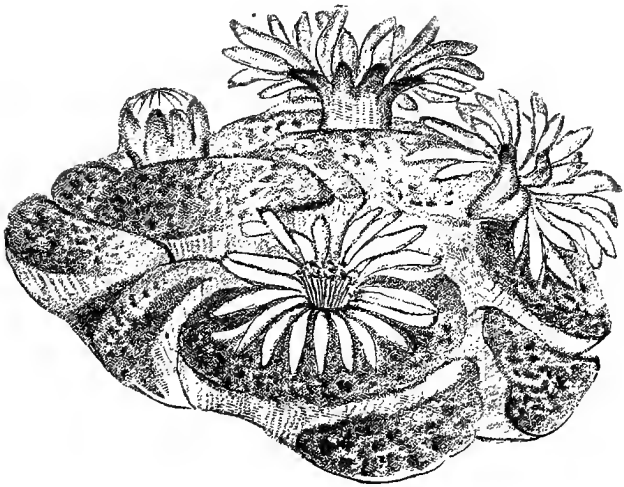
Mr. Ruskin says of the mosses and lichens: "Unfading as motionless, the worm frets them not, and the autumn wastes not. Strong in lowliness, they neither blanch in heat nor pine in frost. To them, slow-fingered, constant-hearted, is intrusted the weaving of the dark, eternal tapestries of the hills; to them, slow-pencilled, iris dyed, the tender framing of their endless imagery. Sharing the stillness of the unimpassioned rock, they share also its endurance; and while the winds of departing spring scatter the white hawthorn blossoms like drifted snow, and summer duns in the parched meadow the drooping of its cowslip gold, far above, among the mountains, the silver lichen spot rests, starlike, on the stone, and the gathering orange stain upon the edge of yonder western peak reflects the sunset of a thousand years."

The term Cryptogamic was employed by Linnæus, meaning hidden flowers; that is, if there were in these plants organs answering to stamens and pistils, he was unable to find them. Since then, they have been found in all but the very lowest orders, but the name, and its English equivalent, "flowerless plants," is still retained; for the answering organs are truly hidden, and their union produces singular, for a long time unsuspected, results.

It would seem as if the lower down we go among plants, the more mysterious and complicated is their behavior. Even when studied under powerful microscopes, it is difficult to grasp in detail their wonderful story. One thing is apparent at first study, and that is, that the cellular arrangement is simpler, presenting none of those "differentiated" cells which appear even in the seed-embryo of the higher plant.

In the vascular division of Cryptogams there is a framework of wood, formed of hardened cell-walls; in the cellular division, no such tough framework exists, only a mass of cellular tissue, one cell adjoining another. In such plants the sap does not circulate, but water passes freely through the cell-walls. The protoplasm which lines the cell-walls is like the protoplasm of the higher plants, and is assimilated in the same manner from air, soil, and water. Since protoplasm forms the tissues of animals as well as of plants, including the lower orders of both, it is not surprising that the boundary line separating the two kingdoms should be blurred and difficult to define. There are plants that look like animals, and animals that look like plants. Take the sea-anemone (animal) and the mesembryanthemum (vegetable) as examples. Who can tell, from their outward appearance, where each belongs? Many animals have no heads, nor legs, nor even stomachs. They are riveted to one spot. Many vegetables are furnished with cilia which enable them to swim freely about, to sport and caper, roll over and over, with every appearance of creatures at play. Many have no leaves, nor roots, nor even

green cells. How, then, are we to know where to assign these lower orders of beings which approach so near each other? Except in the case of parasitic plants, there



VEGETABLE

is one sure test. If the creature lives on air and water, assimilating the gases found therein, it is vegetable, since animals always feed upon other animals or plants.

For a long time the lowest orders of parasitic plants, such as those rod-like bodies called bacteria, were considered animal in their nature. They constitute the great class of harmful plants which M. Pasteur and others have patiently studied. Through the extended re-

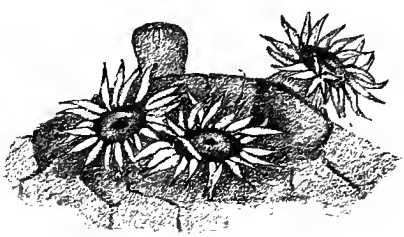
searches of such men, whose works and their results read like fairy tales, we know many things for a certainty, and are likely to know many more, where once all was doubt and mystery. The business of these plants is to disintegrate and destroy. The fungi, ferments, moulds, microbes, cause blight on fruit, disease and death among animals and men. After death they reduce our bodies to decay. Theirs is the mission to bring back "dust to dust." Thus disintegrated, animal life becomes nourishment for other plant life, which in turn supports living animals. Nothing is lost. Life and death are synonymous with change. They follow each other in an endless circle, and there is nothing unchangeable but the soul of man.

HYDROIDS (ANIMAL) GROWING ON A SHELL

The presence of wood among the softer cellular tissues indicates that our plant belongs to the first great division, Vascular Cryptogams. This includes, according to their rank, Equisetums, Filices or ferns, Adder's-tongues, Lycopods or club-mosses, Selaginellæ, includ-

ing Isoetes or quillworts, Marsileas, and the Azolla. Unlike mosses, most of these plants attain some size, and stand erect, and need a tough framework to hold them firm. They are also called Pteriodophytes, meaning fern plants. They are Acrogens, a word which means that they grow by constant additions to their tips, the diameters not enlarging. As the first growth dies, the living tip is left by itself to form a new plantlet, and this is one way of propagation.

Highest in rank are the horse-tails or scouring-rushes. The botanical name of this family is Equisetaceæ. The termination *aceæ* cuts a large figure in botanical nomen-



ANIMAL

clature. After separating it from most words, they are comparatively pronounceable, and indeed recognizable.

Remains of horse-tails twenty feet high are found in coal-beds. With Selaginellas forty or fifty feet high, immense Sigillarias, and large ferns, these plants are among the oldest in the earth's history, and are found in the upper beds of the upper Silurian rocks, in the

EQUISETUM—SPORES WITH ELATERS

lower old red sandstone, in the oolitic, and in the coal formations. In the coal era especially, from Arctic to Antarctic Ocean, they covered the whole earth with rank forests. Forming successive generations of tangled growth in great dismal swamps, these gigantic trees and ferns were prostrated one after another, covered with mud and pressed by sea sand, till peat and coal beds were stored away for the earth's latest era, when man should run his factories, his railroads and steamships by their aid.

The stem of an Equisetum is made up of hollow reeds, jointed, grooved, each joint furnished with upright teeth, which clasp the stem like a sheath. Children like to pull these sections apart, and see how neatly they fit into each other. From some of the joints radiate branches which look like finely-cut leaves. The cuticle of the stem contains numerous fine bits of silica, which made some of them useful for scouring purposes before the manufacture of sapolio. At the top of the stem the fructification is borne. Several shield-shaped bodies containing spore-cases are attached by short stalks to the stem, like a cone. When ripe the spore-cases split open and the spores escape. Spores differ from seeds in that they are single cells, and do not give rise at once to the succeeding fruit-bearing plant. Falling upon the ground, a spore germinates a minute cellular expansion, called the prothallus. Elaters, four hair-like bodies, formed by the splitting of the outer coat, are attached to the spores, and are very susceptible to changes of moisture. When moist they coil around

the spore; when dry they fly open, often with a jerk, which starts the spore from its spore-case.

The horse-tails and all their allies have two generations, one the prothallus, the other the spore-producing.

We have about a dozen varieties. In all there are twenty-five species. The largest, *E. maximum*, is used in Sweden for fodder for horses. They all frequent banks of streams or marshes. The root is a root-stock, and when it is cut gives rise to separate plants. They are therefore very difficult to exterminate.

Ferns, next in rank, will be the subject of a separate chapter.

The Adder's-tongue family has two representatives—Botrychium, or moonwort, and true Adder's-tongue. They are fern-like plants, not common, found in rich woods, unlike ferns in that the first appearing fronds are not circinate, but erect. The fruitage is borne on spikes or panicles. The prothallus is developed underground, and has no green color; it is therefore difficult to find. The spores are copious, yellow in color. The roots often bear starchy tubers.

Lycopods, or club-mosses, are those most used for Christmas decorations. Every one knows the ground-pine and the running-pine. The creeping stem sends up short branches, covered with scale-like leaves. The fertile stalks bear the spore-bearing leaves arranged in cones. The spore-cases are found at the base of the leaves, as in conifers. The cases split around like a clam-shell, and drop the spores, which germinate an underground prothallus of considerable size.

One of the Scotch coal-beds is found to consist almost entirely of the spores and spore-cases of some Lycopod. There are one hundred species (nine with us), some of which delight in great heat, and some in cold. In New Zealand they grow as large as small shrubs. They affect bleak and exposed situations; and many a rock or bare hill-side owes its beauty to the humble Lycopod. The tiniest species grows in bogs with the Sphagnum moss. Our conservatories offer some choice species of Lycopods and Selaginellas. They make beautiful basket-plants, which even orchids need not blush to associate with. Sometimes in a florist's the resurrection-plant from Mexico may be seen. In the dry season this club-moss rolls itself up into a dry ball, and is blown about by the winds over the arid plains. Placed in water it will revive, turn green, and spread out its withered branches like arbor-vitæ.

The spore-powder of club-mosses cannot be wetted. If you rub it over your hand and thrust your hand into water, no moisture can touch your skin. For this reason the powder is used to cover pills. It is highly inflammable, and is used in theatres to produce artificial lightning. It also makes a beautiful blue dye.

Selaginellæ and Isoetes differ from the club-mosses in one important particular. They bear two kinds of spores, small and large. The latter, macrospores, produce the prothallus which bears archegonia. The former, microspores, very numerous, send out the antherozoids which fertilize the archegonia, and develop the second generation of the plant life.

The most common Selaginella is *S. rupestris*, not over three inches high, running over dry rocks, grayish-green in color, looking like a moss. We have only three species.

The Isoetes are so unlike Selaginellæ in appearance, it seems strange that they should be classed together. The common name is quillworts. They are aquatic, often entirely under water. They are grass-like. The leaves are thick at the base, and taper sharply. They lie one over the other, like the layers of a corm or bulb. The spores are found in the bases of the leaves, the macrospores in the outside leaves, the microspores on the inner.

The Marsileas and the Azolla are aquatic plants, rooted in mud, small, but little known. They bear large and small spores. *Marsilea quadrifolia* might be mistaken for a four-leaved clover.

Azolla looks like a creeping moss or liverwort. It is reddish in hue, very delicate and pretty. *A. caroliniana* is our only species.

## XII

## FERNS

Spores Distinguished from Seeds—Two Eras in the Life of a Fern—The Prothallus—Sporophore—Spores—Sporangia—Sori—Indusium—How to Distinguish Ferns

FLOWERING plants, by the union of stamens and pistils, produce seeds. The seed is the fertilized ovule, and contains within itself, in embryo, the exact likeness of the parent plant. This embryo, whether it be the tiny dust of the mustard-seed or the large squash and melon seeds, is composed of a stem, from the upper part of which the bud springs; from the lower, the root and one or two cotyledons. The office of the cotyledons is to provide nourishment for the plantlet. This is called albumen, and furnishes the starch and meal of our cereal grains. In some seeds the albumen contains globules of oil, in others mucilage.

It is only within fifty years that spores have been distinguished from seeds. They are simple, often single, cells. The mystery connected with them gave rise to the superstition that the possessor of fernseed might at will become invisible. Shakespeare says,

"We have the receit of fernseed; we walke invisible."

Long ago, in the carboniferous era, there were gigantic ferns. The hot, moist, marshy forests produced no

color or fragrance, only masses of green cryptogams and cone-bearing plants, all together at length laying down their fronds and stems to form our coal-beds. Perhaps the tree-fern of Australia and New Zealand is a survivor of that age. It reaches sometimes the height of eighty feet, and produces broad waving fronds, only at the summit. These drop off year by year, leaving scars on the trunk. Our ferns are small, and their stems are mostly root-stocks, creeping underground or else over rocks and trees. As in the tree-fern, the new leaf is always at the end of the stem, and dies annually. Considerable time is required to develop the leaves of some ferns. In one species (*Aspidium filix-mas*) they are two years in forming before they unroll.

TREE-FERN

The ferns we love best are the small and delicate varieties, with their wonderful forms of foliage. The

maidenhair dipping its tresses in the brook, the tangles of shield-fern, Dicksonias, Woodsias, bordering the forest paths, standing late in autumn, white and fairy-like, these are favorites with every one, unless perhaps those to whom they are common.

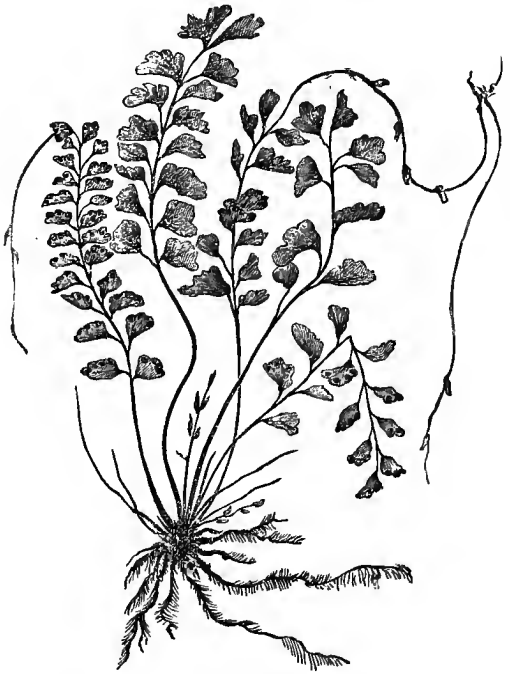
Said a country farmer to his wife, after taking a party of city girls to drive: "They said oh! and ah! and went just wild over—what do you think?—a passel of brakes!"

The leaf of a fern is a frond. Its divisions are pinnæ, and subdivisions pinnules.

There are two eras in a fern's life. The graceful frond which we see, and which (if fertile) bears brown dust-like spores upon its back, represents the second part of its life, and is called the spore-bearing period—sporophore. Previous to this, and almost invisible because so small, is the oophore, or germ-bearing plant.

The spore falls upon a moist surface, like a flower-pot or the wall of a greenhouse, and, by an expansion of its inner coat, produces a minute thing called a prothallus. It is green and membraneous, irregularly heart-shaped, held fast by little root-hairs. If the green mould upon the surface of the greenhouse pots be studied with a microscope, one may be fortunate enough to discover some of these prothalli developing the fern plantlet. Near the notch of the prothallus, underneath it, soon appear pistillidia, or archegonia, and antheridia. The former are the organs to be fertilized, and are bottle-shaped depressions in a thickened part of the prothallus, each containing a nucleus or central cell. The an-

theridia are cellular excrescences, which when swollen with moisture burst, and set free, not pollen-grains, but spirally-twisted self-moving bodies covered with hairs,



A FERN

which travel freely over a wet surface, till they find and penetrate the pistillidia. Sometimes they travel to other plants and produce hybrid ferns. From this strange

union, which, after all that has been learned, remains a mystery, the first fern-leaf is developed; and the prothallus, having performed its office, dies.

A leaf which unrolls, as do most fern-leaves, is circinate. The stem, or stipe, of the frond is variously colored—brown or purple or black. It is frequently covered with soft silky brown chaff, adding greatly to its beauty. I have found the *Aspidium marginale* with velvety chaff an inch long.

The spores are borne on the backs of fertile fronds, at the end or on the side of the fertile vein. They are collected in spore-cases, or sporangia. These are capsules, mostly stalked, made of walls one cell in thickness, surrounded by a ring of cells. The ring contracts in drying, causing a rupture of the spore-case and scattering of the spores. True ferns open by a slit across the sporangium. Others are slit vertically, or broken into equal valves.

The sporangia are collected in dots or lines or clusters, called sori, along the veins or margins of the fertile fronds. Sometimes the sori occupy the entire space, crowding out the interspaces of the leaf, forming a continuous spike of fruitage. This is true of the sensitive-fern (*Onoclea sensibilis*) and moonworts (the botrychia). The name of the latter is derived from a Greek word meaning a bunch of grapes.

The sori are sometimes naked, but more often are covered with part of the leaf called the indusium.

In the maidenhair (*Adiantum pedatum*) the lobe of the frond is folded backwards to form the indusium.

In the common brake (*Pteris aquilina*) the continuous sporangia are covered with a very narrow reflexed edge of the entire frond. Generally the indusium is a part of the epidermis, raised from the leaf, or it may be a scale.

The *Polypodium vulgare* is a stiff, handsome fern with large naked yellow fruit-dots on the upper pinnæ of the fertile frond. They can be studied easily with the aid of the botany-glass, and the escaping spores can be seen.

In the Asplenia the fruit-dots are long, covered by indusia attached to the upper side of the veins. In one of these, the *Asplenium Filix fœmina*, the indusium crosses the vein and assumes a horseshoe shape.

The Aspidia may be recognized by round fruit-dots, covered by an indusium fixed in the centre and open all around, or fixed on one side and kidney-shaped. The Dicksonias have cup-shaped indusia.

FERTILE FERN, OF COMMON BRAKE, WITH SPORANGIA

One curious fern is the walking-leaf (*Camptosorus rhizophyllus*), whose slender frond tapers into a kind of runner, which drops to the earth, takes root, and gives rise to a new plant. The indusia are mostly in pairs,

forming crooked lines of uneven lengths, giving the fertile frond a singularly marked appearance.

There are two beautiful rock-ferns, with dark shiny stipes (asplenia), often growing together. The delicate leaves grow in tufts, in crevices, and upon surfaces where a little earth has lodged, enough for them to take root in.

One of the smallest ferns is the *Schizea pusilla*. Its sterile fronds, scarcely an inch tall, are like twisted blades of grass. The fertile are three or four inches in height, bearing about five pairs of crowded pinnæ, containing large ovoid sporangia. Owing to its small size, one must look sharply through the pine barrens of New Jersey to find it.

Many places are rich in ferns. In one of Connecticut's hilly towns I have found twelve species. New Jersey boasts many, as do our rich woods everywhere. Some of the finest grow along the Alleghanies, high and rank, fit associates of the noble hemlocks in whose shade they luxuriate.

It is quite as easy to study ferns as flowers. The student's microscope will answer every purpose for determining the shape and position of sori, on which the classification of the fern depends. And the collection of ferns is an occupation possessing peculiar fascination, owing to the perfectness and beauty of the pressed and mounted specimens. Fortunately the craze for trimming picture-frames and filling winter-vases with dried ferns and grasses has almost passed away, but not until the graceful "Hartford fern," the *Lygodium palma-*

*tum*, has been nearly exterminated by thoughtless young people, who pulled it up by the roots. Boys gathered it in quantities, and sold it on the streets of New York City. From being abundant in Connecticut pine-woods, it is now marked in the botany "rare."

## XIII

# MOSSES AND LIVERWORTS

### (BRYOPHYTES)

Charm of Mosses—Growth and Propagation—The Protonema—Gemmæ—Peat-mosses—Thallose and Leafy Liverworts—Macrospores—Interesting for Microscopic Study

THE second great division of flowerless plants is that of cellular cryptogams, or Bryophytes, a name meaning mosses. In these the woody frame is wanting. Being small, many of them invisible to the naked eye, they do not need a fibrous skeleton, and they are composed of cellular tissue alone. The mosses constitute one subdivision, and include leaf-mosses (*Musci frondosi*) and the hepatic-mosses (*hepaticæ*). Thallophytes form the second subdivision, including algæ, lichens, and fungi.

#### MOSSES

It is difficult to define the charm of these little plants. Whether it consists in their delicate tints of red, gray, brown, and green, whether in the graceful festoonery with which they cover unsightly objects, stone-walls, old ruins, bare rocks, whether in the fine pencillings of their tiny leaves or their associations with the most beautiful spots in the woods, certain it is that mosses

possess an attraction for us all their own, very different from that of trees or flowers or ferns. We tread lightly over their beds of plush; we sit down among them; we love to gather and arrange them with partridgeberry vines and small ferns in miniature landscapes for house decorations. The moss-basket with trailing vines is a rival to the vase of roses.

To the botanist, mosses are a source of unfailing interest. Their manner of growth and propagation is different from anything we have yet studied. There are sexual bodies, but the plant is not dependent upon them for its new growths. The lower we descend in the scale of plant life, the more bountifully do we see that Nature has provided for the preservation of her humble offspring, so that if one means fails to continue the species, another may be substituted.

In early spring there may be seen arising from a bed of moss, myriads of hair-like reddish stalks, each bearing at its apex a little cup, or urn, covered with a pointed cap like the children's soldier-caps. The cup contains spores, and they are protected from rain while they are ripening, not only by the cap, but also by a close-fitting lid, or by rows of teeth, very susceptible to moisture, or by both. Thus shielded, the little moss-plant may laugh at the storm which uproots the forest giant. In its very lowliness it is safe from the lightning's shock and the hurricane's overthrow. When the spores, four in each cell, are ripe, off goes the cap, now quite useless. The hygrometric teeth are even in number, and are 4, or a multiple of 4; 8, 16, 32, or 64. In sunshine they open,

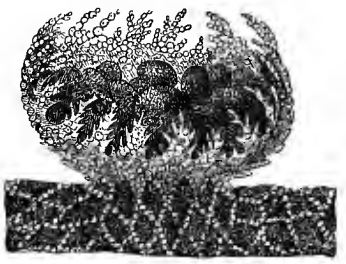
and dampness causes them to close. By breathing upon a moss capsule, one may see the teeth close. Then if held in sunshine, or near a fire, they will expand with a perceptible motion. When the spores are ripe, the teeth and lid open, or fall away, the stalk turns, and the capsule is tipped upsidedown.

In germinating, the spores, like those of lycopods and ferns, do not produce the moss-plant directly, but a finely-branched, vegetative, and nutritive proembryo, or protonema. It looks like a sea-weed. It spreads over the ground, to which it adheres by small roots. From the basal cells of the protonemata, the new moss-plants are formed. Several may grow, the product of one spore. Upon the summit of one of these stems (in sphagnum upon the sides), looking like leafy buds, appear upon some stems, archegonia (answering to flower-pistils); upon others, antheridia (corresponding to stamens). Every cell of the antheridia contains one antherozoid furnished with a pair of freely-moving whips. These, swimming in water, find the flask-shaped archegonia, the neck of which is mucilaginous, enter and descend to the ovum-cell, which, being fertilized, gives rise to the hair-like stalk, producing the spore-bearing capsule with the pointed cap. Such mosses are called hair or urn mosses. Since they grow in moist places, and hold dew or rain like a sponge, there is always water present for the whip-like bodies to swim about in.

Other methods of propagation are from the rootlets, each one of which may give rise to a separate proto-

nema and moss-buds. In some mosses the protonema never seems to die, but generates new plants every year.

There are also gemmæ, which look under the microscope like "silver-tinted nests." They are store-houses of nutritive material, and can give rise to protonemata, or directly to moss-buds. It is no wonder that mosses are so ubiquitous, and recover so readily from injuries, such as the cropping of grass-eating animals.



GEMMÆ

Any one who wishes to watch the progress of moss-plants from the spore can toss some of the spores from a ripened capsule, called the sporogonium, upon a dish of wet sand, and see the growth of the protonema as it spreads over the sand.

The peat-mosses, sphagna, are formed by successive generations of living stems, the older dying and supplying nourishment to the newer. A peat-bed is probably made in this manner: In a hollow among the hills some trees fall and decay, forming a soil which mosses love. They begin to grow, and in their spongelike masses produce little bogs, which in the end are fatal to all indigenous trees or shrubs. These decay, fall, and are covered by the ever-rising generations of sphagnum.

Peat-bogs form a tenth part of Ireland, and occupy large areas in Scotland. Dried in masses, peat forms the cheapest fuel in existence, and it has been the greatest friend of the Irish peasantry.

The common hair-moss is found in every wood. It may be known from its having a lid to cover the capsules, besides thirty-two or sixty-four hygrometric teeth.

### HEPATICÆ

A still humbler order of plants is that of the liverworts, or hepaticæ. They do not cover large extents of surface, and being in our latitude small, are likely to be overlooked by the amateur botanist, or mistaken for lichens. In moist shady dells, where the water trickles down rocks, they can generally be found.

The Rev. Hugh Macmillan says, in his *First Forms of Vegetation:* "The greatest number of species occurs in the tropics, and nowhere do they luxuriate so much as in the dark woods of New Zealand. Some of them grow in the bleakest spots in the world, and are to be found even at a higher altitude than the urn-mosses, on the great mountain ranges of the globe. They form the faintest tint of green on the edge of glaciers, and on the bare, storm-seamed ridges of the Alps and Andes, where not a tuft of moss or trace of other vegetation can be found."

The vegetative body is either a flat cellular expansion, a thallus, or a branching stem, with small leaves like scales overlapping or underlapping one another. Thus

they are divided into thallose and leafy liverworts. The latter are better known as scale-mosses. The order comprises thirty-one genera, under the families Jungermanniæ, Marchantiæ, and Ricciæ. The latter two are

MARCHANTIA

thallose. The Jungermanniæ include all the scale-mosses. In the scale-mosses the spore-capsule splits into four valves, which, when spread open, look like the sign of plus (+). Mixed with the spores are elaters, called macrospores—yellow filamentary bodies, which coil and uncoil and writhe and twist like so many worms. The first time one sees them in the field of the microscope one is filled with astonish-

ment. They roll over and over, push against each other, so like animals and so unlike plants it seems impossible to relegate them to the unconscious vegetable world. Their office is to push the spores out of their cups and help to disseminate them. The sexual bodies are similar in growth and operation to those of mosses, already described.

The leaves of nearly all liverworts are double, with an under and upper surface. From the under spring rootlets, each a single tubular cell; from the upper, in depressions, or on stalks, or sessile, are produced the organs of fructification.

ANEURIS PINGUIS

A curious genus, riella, is found in Sardinia and Algiers on banks of streams, growing two or three inches high, with the thallus wound spirally around the stem. In the male plant antheridia are produced on the edge of this wing; in the female the archegonia grow in clusters along the stem. It is unique, a very remarkable form of vegetable life.

FRUIT OF LIVERWORTS

The *Marchantia polymorpha* is one of the commonest of thallose liverworts, forming large dull green patches on damp pots or on the walls of greenhouses. Its fronds are about three inches long, and on them appear small mushroom-like bodies, bearing antheridia on the upper, archegonia on the under sides. These are the inflorescences. Gemmæ like those of mosses are produced, and also, as in mosses, separate plants grow from individual rootlets.

The scale-mosses under a microscope look like lizards or curiously-shaped reptiles. There are many varieties, with different forms of inflorescence.

*Riccia natans*, or crystalwort, is an aquatic species. Numerous air-chambers appear on the upper side of the thallus, which help it to float on stagnant water, and in which the fertilizing bodies are immersed. The under side of the thallus is furnished with a row of purple scales, from which, if the plant finds itself over mud, the water evaporated or drained off, rootlets spring and

fasten the plant to the earth. Thus it can adapt itself to quite different conditions of growth.

These plants owe their name to their having been formerly considered a cure for liver complaints. Where they are plentiful, after a shower they sometimes emit a strong musk-like odor, like the smell of moist earth. They are of no use, but for microscopic study of cellular tissue are invaluable. Many foreign species can be cultivated along with ferns in a moist cold-frame, and doubtless will in time find great favor for the same reasons which make ferns popular—their delicacy of tint and form, their graceful and unique growth.

## XIV

## LICHENS

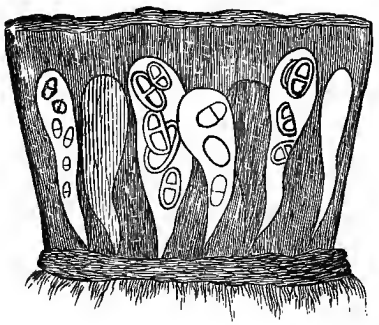
Lichens Perennial, not Parasitic—Reindeer-moss—Iceland-moss—Manna—Propagation—Nomenclature

This is the forest primeval. The murmuring pines and the hemlocks
Bearded with moss, and in garments green, indistinct in the twilight,
Stand like Druids of eld, with voices sad and prophetic,
Stand like harpers hoar, with beards that rest on their bosoms.
—LONGFELLOW: *Introduction to "Evangeline."*

A LESS poetic nature than our Longfellow's could see the resemblance of many a forest tree to an old man with a long gray beard. The older the tree, the more venerable it looks, with its gathering investiture of sombre lichens. The colder the climate, the thicker the lichens grow, as animals of arctic countries are dressed in warm fur. The north and most exposed side of the tree gathers the greatest number of lichens, and the knowledge of this fact has helped to guide men lost in a pathless wood when there were no stars to direct them.

Lichens alone are really perennial. Growing for two or three years rapidly, they then cease to hurry, and some have been known to be forty-five years old when

they were just beginning to fruit. They cover bowlders and ancient rocks. They creep over tombstones, obliterating the figures carved centuries ago. Indeed, it is supposed that the "primeval" trees are not older than their humble clinging companions. Who can tell how long the "lichen-stain" has decorated the bare peaks of lofty mountains, the rocks otherwise utterly bleak and devoid of vegetation?



THE COMMON CUP-LICHEN, MODERATELY MAGNIFIED

Lichens have two lives, alternately of activity and repose. When it rains, they spread out their leathery aprons or their coral-like branches and grow and thrive. When the drought comes, they shrivel up, not to die, but patiently to wait till the glad rain comes again. After being pressed half a century, their spores will swell in water and grow.

Their rootlets serve only to attach them, and how securely this is done any one knows who has tried to pull them off without breaking their fronds. They are not parasitic, except sometimes upon each other, and they do good rather than harm. The cinchona-

tree which is covered with lichens is rather improved in its medicinal qualities, while fungi fastened upon the same bark will deprive it of all virtue. In the desert lichens quickly cover the bleaching bones of animals. They increase in luxuriance from the tropics to the arctic regions, where they grow often many inches thick all over the ground. They are an indication of clean and healthful conditions of atmosphere, very few growing in the smoke or impure air of our crowded cities.

The famous reindeer-moss (*Cladonia rangiferina*) covers the soil of whole pine forests in Lapland, and forms the principal food of the Laplander's greatest friend, the reindeer. If the forests happen to be burnt down, the lichen soon reappears. The sight of reindeer feeding in one of these creamy moss patches is as much a picture of pastoral content as that of cows in a meadow. When the snow covers the cladonia so that the reindeer cannot dig it out, there is a poor substitute growing on the pine-trees—the *Alectoria jubata*—a black hair-like moss which will support life for a time. The owners of the reindeer cut down trees in order to bring this food within their animals' reach. Indians steep it in water, and make it into flat black cakes, insipid and distasteful to the white man.

It is a lichen, the *tripe de roche*, which men in arctic expeditions are forced sometimes to eat. It is poor food, not much better than leather, and produces griping pains.

There is an edible lichen which makes a nourishing

blanc-mange and a drink useful in pulmonary complaints—the Iceland-moss (*Cetraria islandica*). It is the Esquimau's principal vegetable food, and is very nutritious, containing forty-seven per cent. of lichenine or starch. It grows on lava fields to a very large size in Iceland, and is collected and dried by the ton for winter use.

The *Usnea florida*, growing upon rocks, is a favorite food for goats.

It is supposed that the manna eaten by the Israelites in their passage through the wilderness was a lichen found in Eastern countries, the *Lecanora esculenta*. Showers of this are torn from its native place by the wind, and are carried for miles, in Persia and Russia. Sheep are very fond of it. It is grayish-white, varying in size from a pin's head to a pea or nut, and will fall in such quantities as to cover the ground three or four inches deep.

As dyes, lichens have a commercial value. They make beautiful blues, purples, and dark reds.

Wolves were at one time successfully poisoned in Russia and Norway by a species of lichen mixed with powdered glass.

Oxalic acid is made in France with one species. As drugs, however, they have at present no use. Bird-fanciers gather them and decorate twigs, making miniature forests for the birds in rooms or large cages. The great use of lichens, however, is to disintegrate rocks, reduce their surface to powder, and form soil for higher orders of plants to grow upon. For this purpose

they are one of nature's most persistent and effective agencies. They are propagated in various ways.

The gonidia, a layer of green cells in the thallus, under a transparent cover called the hypha, divide each one into two, and form new plants. They are parasitic upon the lower strata of the thallus.

Upon the margins of a thallus still different organs of reproduction are found, pycnides, simple filaments, with rounded bodies at their ends. These are a kind of spore. In order to give an idea of the nomenclature with which a lichenist must be familiar, we quote the description of some of the genera as given in the Nylanderian classification, from the Encyclopædia Britannica.

Tribe 1, Sirosiphei, of Family 1, Ephebacei, may thus be known: "Thallus filamentose, fruticulose, gonimia variously connate. Apothecia biatorine or lecideine. Spermagones with sterigmata or anthrosterigmata."

Tribe 23 may be recognized from the following description: "Thallus variously crustaceous, pulverulent, evanescent, or none proper, with the gonidium stratum consisting of gonidia (rarely chrysogonidia, rarely gonimia). Apothecia lecideine (or biatorine). Spermagones with simple or simplish sterigmata."

Most of us will doubtless be content to call a lichen a lichen, and to know it from a moss or fungus, occasionally taking a peep through our microscope at some of its wonderful organs with the more wonderful names.

## XV

## ALGÆ

Offices of Roots and Leaves (or Fronds) of Algæ—Spores—Large Sea-weeds—Edible Algæ—Colors and Distribution—Red Snow—Diatoms

THALLOPHYTES form the second division of Bryophytes, including algæ, lichens, and fungi, mosses and liverworts being the first. Although low in the scale of vegetable life, many of them have the most intimate connection with our domestic life and with our agricultural success. A practical knowledge of their structure and habits has to do with the very well-being of the race.

Algæ—sea-weeds—have organs similar to roots and leaves. The roots, however, do not extract nourishment from the soil. They adhere to some fixed place, and allow the plant to sway its fronds in the water with greater freedom. The leaves are cell-expansions, often single cells distorted in several directions.

The spores have a tendency to divide into four parts, and are called tetraspores. They are provided with cilia, either in pairs or all around their ball-shaped bodies, which send them tumbling about till they find a firm place whereon to establish themselves. Each cell seems capable of propagating two new plantlets by division. Another remarkable means of propagation

is by "conjugation." Two cells approach each other. Each bulges out towards the other. At length the swellings touch, unite, burst the partition between them, and form a tube through which the contents of one cell pass into the other. From this union a vigorous plant is formed, which, by cell-division, gives rise to many more.

SEA-WEED MAGNIFIED, SHOWING SPORE-SACS

Many of the algæ are immense growths. The macrocystis is found from three hundred to seven hundred feet long. The tree sea-weed, *Lessonia fuscescens*, may have a stem ten feet long, twelve inches in circumference, with fronds two to three feet long. Sometimes algæ grow in great patches or meadows, as the famous Sargasso and the Gulf-weed. For miles the water is tinted green or red with such algæ. Their stems twist into great cables hundreds of feet long. They are found in all waters, from the polar regions to the tropics, on icebergs, on snow, in freezing water, and in boiling springs. The desmids and diatoms are the smallest, visible only under powerful microscopes.

The gulf-weed, so familiar to travellers crossing the Atlantic, seems always floating, never fixed. It is called sea-grape, from the resemblance of its air-sacs to berries.

GULF-WEED
(Sargassum Bacciferum)

Many algæ are edible. The dulse of the Scotch and the tangle of the Swede are made from algæ. The Chinese are supposed to make soup of certain species of

jelly-like algæ. Many of these plants are single cells, held together by masses of gelatinous matter.

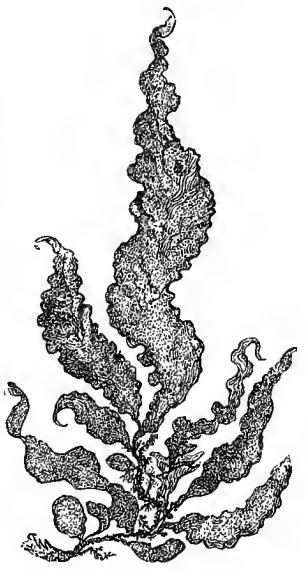
They are divided, according to their color, into brown, red, and green sea-weeds. The brown love the warm waters of the equatorial regions, the red inhabit mainly the temperate zones, and the green thrive best in the cold waters which lap the icebergs. There are some six thousand species of marine algæ. Those which grow in fresh waters are called confervæ. The great lakes of North America are said to have none.

COMMON SEA-WEED

There is a green scum-like growth, known as "frogs'-spittle," found upon stagnant ponds. Under the microscope this resolves itself into thousands of slender green filaments, each one a hollow tube, containing grains floating in mucilaginous matter. These and similar organisms, which we are apt to associate with malaria and filth, are, in fact, not the cause, but simply the indications of unwholesome conditions, which they do their best to remove. They assimilate the decaying organic matter which these places contain, and are themselves food for animalcules, which swarm among them. The zygnemas are composed of long tubes joined together

by short ones, all marked with beautiful spirals or crosses, or other regular figures. They are large confervæ, and are found in great numbers fifteen thousand feet up the Himalayas, in the cold springs which rise from the glaciers.

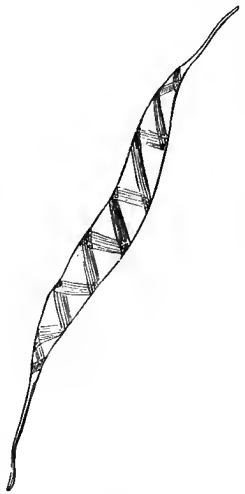
The famous red-snow (*Protococcus nivalis*) is a minute red alga, consisting of little granules from $\frac{1}{3000}$ to $\frac{1}{1000}$ of an inch in diameter. It is a cell containing starch and nitrogen; in other words, protoplasm. This substance occurs not only on snow and ice, but in hot-house water-tanks, on rocks within reach of the ocean's spray, and on decayed leaves and mosses. An allied alga is the *Pamella cruenta*, deep red in color, found upon stale bread and meat, or upon musty walls of houses. The color, blood-red, has often terrified ignorant and superstitious people, who thought the heavens rained blood, or the sacramental host was bleeding, ominous of divine vengeance for sins. More than one poor creature has been burned, charged with being a witch,



SEA-WEED

for no better reason than that red algæ, resembling spots of blood, have been found in her dwelling.

A most graceful thing is the batrachospermum, found on stones in little streams everywhere. It is brown, yellow, or purple, with pretty fern-like fronds. It may be plunged into boiling or freezing water without apparent injury.



ZYGNEMA

One species is found only in wells.

The smallest of all algæ are soft cellular tissues with silicious shells. They are the diatoms, which abound in water and moist atmosphere. From two to twenty thousand placed alongside will measure an inch. When the first Atlantic cable was laid, the dredging-machine brought up myriads of these atoms, the delicate striæ of whose shells were marvellously beautiful. They were long thought to be animalcules. Ehrenberg, an eminent German microscopist, so classified them; but their mode of reproduction, by cell-division and by conjugation, assigns them to the vegetable kingdom. Sometimes they accumulate on larger sea-weeds, or they cover submerged twigs like a brown fur. Mollusks and other small creatures feed upon them. They are of

every shape, round, square, oblong, crescent, always regular, composed of soft tissue, covered by two silicious shells. The smaller half fits inside the larger, as a box slides under its cover. Each half is surrounded by a projecting rim. When the cells are ready to divide, new rims form within, on the side opposite the old ones. At length the enveloping ring bursts, and the two halves separate, each a complete new individual. It is computed that one billion descendants may arise from a single individual in a month's time.

When these organisms die, their hard shells fall to the bottom of the water, and the ocean-beds, as well as many beds of lakes, are covered with them, often to a great depth. There they harden into solid rock. Near Richmond there is a famous deposit, forty feet deep and several miles in extent. The material is used in the manufacture of dynamite; also as a polishing powder. Fossil diatoms of the tertiary age are similar in every respect to those found to-day. Dust-storms of diatoms are produced by the wind laden with these atoms. They give the chrome color of the Yellow Sea. Hot ashes from volcanoes contain them, and in moist atmosphere nearly everywhere they abound. It is a curious fact that the spectrum of the soft contents of diatoms is identical with that of chlorophyl—another proof that they are vegetables.

One thing must impress every observer of the lower forms of both animal and plant life; that is, the tremendous debt we owe to the microscope. By the aid of its mighty vision new worlds are constantly revealed

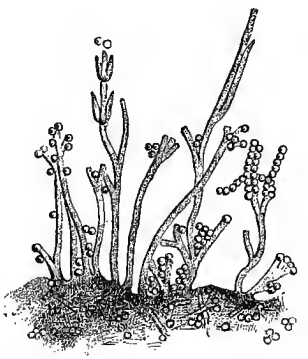
to us. It is not only the starry heavens, brought nearer by the telescope, which claim our attention and make us marvel at the vastness of creation, but just as much the minute things, a hundred of which are no bigger than a grain of sand. The perfection of these tiny organisms, their exquisite adaptation to their conditions of life, the purposes they serve in that realm of nature where there is no waste of energy, no loss, where there is room for every created thing, and provision for its maintenance—all these wonderful facts excite our highest admiration and arouse in us a little of that scientific enthusiasm which tempts others to spend years in the study of microscopic objects. Men are more and more unlocking the storehouse of nature's secrets, and judged by the beneficent results of their labors, such pursuits are as worthy of encouragement as are the discoveries of new planets and the central sun of our solar system.

## XVI

## FUNGI

Lowest Forms of Vegetable Life — Harmful and Beneficent — Wholly Parasitic or Sacrophytic — Reproduction — Rapid Growth and Short-lives — Six Families — Mushrooms — Puff-balls — Fungi Attacking Cereals — Potato-rot, Moulds, Ferments — Bacilli and Bacteria — Antiseptics

The lowest forms of vegetable life are found under the third subdivision of Thallophytes—fungi. They include many harmful as well as beneficent growths. It is a fungus which causes our bread to rise. Yeast is the spawn, moistened flour the favorable soil. Planted within the dough, it takes but a few hours for the yeast-fungus to ramify and multiply itself a hundredfold. During the process carbonic acid is formed, which rises to the surface in the form of bubbles, and escapes into the air. If arrested at the right moment by baking, the fungus

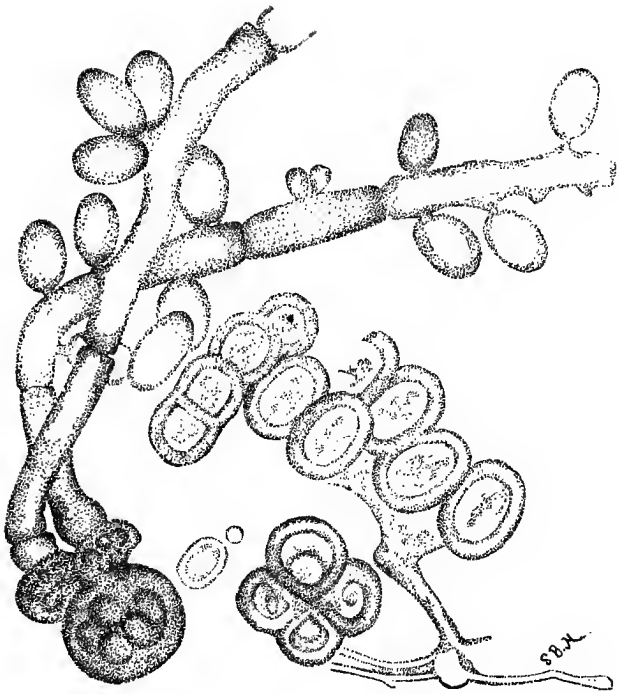


MOULD

is killed, and the bread is light and sweet. If left too long, till the fungus begins to fructify, the bread is sour. Fermentation is induced by a fungus. It is one of these plants which turns cider to vinegar; it is the "mother," and may be found in any unstrained vinegar in the form of a yellowish cloudy substance at the bottom of the vessel.

A fungus spots and spoils our ink. It is a bad fungus which ruins our carelessly prepared cans of fruit, which gathers on jellies, and is one of the first symptoms of decay in stale meats and vegetables. Sugar and saccharine matter furnish a favorable soil for the ferment-fungus. We call such plants mould or blight, mildew or rust. A crust of bread in a damp place is soon covered with blue mould. Under a microscope this looks like a forest of tiny ferns with branching stems, a fine spore dust moving over all. The green mould of cheese, the mother of vinegar, and the yeast-plant, when much magnified, assume unmistakable vegetable forms. The spores of such plants abound in the atmosphere, hovering over us like birds of prey, waiting for a soil of dead or decaying organic matter, to pounce upon it, and absorb it into their own growths. The unwary house-keeper, the careless farmer, alike have reason to dread the ubiquitous, harmful fungi.

This class of plants is wholly parasitic or sacrophytic. That is, they live upon living animals and plants, sucking their juices, and eventually killing them; or they revel in that which is dead and decaying. They are the ghastly corpse plants, the life out of death.



GRAPE-FUNGUS

One has often seen, after a rain, the lawn, or the base and roots of an old tree, or the neighborhood of a cellar window, covered with toadstools, the growth of a single night. In such cases the presence of impure conditions of soil and atmosphere is indicated, and the dormant spores of fungi needed but moisture to cause them to germinate. Let it be understood, the mush-

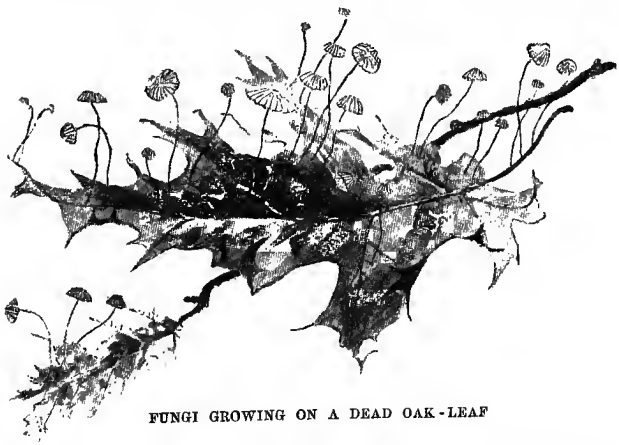
rooms themselves are not the cause of the impurity of the soil, any more than hyenas and vultures are the cause of pollution. The carrion-feeders, both animal and vegetable, do their best to remove putrefying matter. They are nature's scavengers, and we could not do without them, disgusting as their office may seem to us.

Organs of reproduction are found even in this low order of plants. The usual manner of propagation is by "conjugation," already described. Spores do not give rise directly to fungi. They produce a "spawn," smaller, and consisting of numerous filamentary bodies. These are so minute as to be able to enter the stomata of leaves, the rootlets of grains and grasses, the pores of the skin of animals, etc. Zoospores are also produced movable, like animalcules. These may be hidden in a pair of cotyledons, to develop later and prey upon the growing plant. Zoospores enter the leaves of the potato-plant, pass through the stem into the tubers below-ground, from which they extract all the starch, leaving nothing but a black rot in its place. They are so minute, they can occupy intercellular spaces of plants, and from there penetrate cells and extract the cell contents for their own growth inside the stem. In recalling the terrible sufferings of the Irish who have been the victims of potato famines, can we deny that the fungi have an intimate connection with the very life of the human race?

Propagation is mostly effected by cell division, each cell becoming two, and so the parent of myriads of

offspring. Fortunately certain conditions of air and soil are unfavorable to these destructive parasites. Were it otherwise, grains, grasses, and fruits would always succumb to their destroyers, and man's work in the ground would be in vain. As it is, the fungi may be very destructive one season and inactive the next. Scientific men are now giving great attention to the fungi which destroy vines, grains, etc., and it may be that remedies will be discovered enabling the farmer to wage successful warfare against these tiny but powerful enemies.

The tints of fungi are sombre. They seem, like autumn flowers, to presage the winter of decay to all



FUNGI GROWING ON A DEAD OAK-LEAF

that live. Mushrooms grow rapidly where leaves fall and decay. Trees which have stood the storms of cen-

turies, when once they are laid low, are covered with parasitical growths, which reduce them in time to a mass of greasy, filthy black dust.

One of the most remarkable facts about fungi is the rapidity both of their growth and decay. A summer storm is pretty sure to fetch them from every rotten stump or heap of manure. In a single night great puff-balls are formed.

Some of these rapidly growing species develop so much energy as to lift large stones out of place. In such instances no new cells are formed. The old ones merely elongate. As a rule, those which grow so quickly perish in a few hours or days. The spores retain their vitality for months.

The *Tuber cibarium* is a puff-ball formed underground in young beech or oak woods. It looks a little like a pineapple, being covered with excrescences. Inside it is white, with brown grainings, which are the reproductive parts. It is the truffle of Great Britain and the Continent, and is esteemed a table delicacy. Dogs are trained to hunt for them. Pigs are very fond of them, and dig several inches into the ground for them.

From the spawn of mushrooms and kindred fungi appear first tubercles, small round bodies, which gradually rise upon a thick stalk and expand into a flat umbrella-shaped top. This is the pileus, or cap. At first a thin veil covers it, which, as the pileus expands, is ruptured, and remains as a ragged ring around the stalk. Next, on the under surface, radiating from centre to circumference, appear brown or pink, purple

or white, gills or lamellæ. This is the hymeneum, and produces spores. It consists of long narrow cells—basidia—from each of which originate four small filamentary spores, variously colored, in motion. Some of the basidia are flask-shaped, and contain no spores.

There are six families of fungi, beginning with the highest:

1. Hymenomycetes—naked fungi.
2. Gasteromycetes—covered or stomach-like fungi.
3. Coniomycetes—dust fungi.
4. Hyphomycetes—web-like fungi.
5. Physomycetes.
6. Ascomycetes.

To the first family mushrooms and toad-stools belong. The edible fungi are constantly gaining in favor. There are a great many wild species in America, especially in the South. In the time of the Civil War the Confederate soldiers found them an excellent substitute for meat. Near New York, great numbers are cultivated in cellars, or else in long dark sheds. They are, perhaps, the most profitable of all vegetables to raise, judging by the high prices demanded in the markets. On long shelves, two or three rows deep, eight inches of solid manure are thrown. Sod covers this, which is worked well into the manure. The spawn is purchased in flat, dirt-brown cakes an inch thick. This is broken into bits and planted in furrows. It spreads through the soil, and gives rise to a thick growth of tiny globules, which in two or three days' time become as large as the top of a teacup. About every three

months the spawn exhausts itself, having extracted all the nitrogenous substances from the soil, and the shelves must be cleared and new soil prepared. This is the principal expense in their cultivation, and the trouble is slight. If allowed to stand long after being gathered, mushrooms become tough and leathery. They are bought mainly by the large restaurants of our cities, and are usually served broiled with beefsteak, or stewed and covered with a cream gravy. A small white caterpillar, much like a chestnut worm, burrows into the pileus, and is doubtless often broiled and eaten with the mushroom, since its presence is not easily discoverable from the outside.

Of the wild mushrooms, the safest way is to let them alone, since a mistake in applying the tests might be fatal. There are tests, however, as that all species whose stems on being pressed change from yellow to blue, or which have red stems or gills, are to be shunned as poisonous. If they can be easily skinned, and are pink underneath, they are said to be safe for cooking and eating. Such are found plentifully on damp days along the coast.

Many of the noxious species produce intoxication. The convicts of Siberia use for this purpose the fly-agaric. It is rolled into balls and swallowed whole, when its effects are similar to those produced by opium. If a light dose is taken, the person is affected as by inhalation of laughing-gas. He will talk excitedly, or sing, or dance. If a straw is placed in his path, he will jump several feet high in stepping over it, and thus afford no

end of amusement to his friends and lookers-on. If too strong a dose is taken, convulsions and death follow.

The common puff-ball deprives one who has eaten it of all power of motion, while his consciousness remains, thus producing a sort of terrible trance resembling death.

Species sold in Paris markets are grown in catacombs.

Puff-balls and truffles belong to the second family, which contains both poisonous and edible species.

To the third class belong those injurious fungi, smut, bunt, rust, etc., which affect our cereals.

Smut attacks corn. Every one has noticed in a corn-field some heads swollen, gray or black. This is the fungus parasite *Ustilago carbo.* It converts grains of corn into foul, greasy dust. One ear of corn thus diseased is capable of disseminating myriads of spores.

Wheat is invested by *Tilletia caries.*

Grass is subject to *Puccinia graminis,* an orange-colored powder on the leaves in spots of rust.

Ergot attacks rye, and may cause the complete failure of a crop. It is the fungus *Claviceps purpurea.* The grain swells, curves, turns first violet color, then black. If the affected rye is retained and ground with the good grains, and bread made from the polluted flour is eaten, the effects upon the human system are very distressing.

The potato-rot is a fungus (*Peronospora infestans*) of the fourth order. Nearly all vegetables — tomatoes, spinach, carrots, turnips, beets—may be attacked by the same or a nearly allied fungus. Zoospores enter the stomata of leaves, pass into the roots, and there work

destruction. Under this order of the web-like fungi, so named because the spores appear as if covered with a whitish web, come also the moulds and mildews.

Moulds are blue, green, or yellow. Blue mould attacks oranges. When they are ready to decay, a dark spot forms on the outside, greasy and velvety to the touch. Under the microscope the rind of an orange thus affected presents a view of numbers of stalked spores, or spores linked together in chainlike rows. Orange groves sometimes suffer from the black mildew, which attacks leaves and stops up the stomata. The mulberry-tree is liable to attacks from the same fungus.

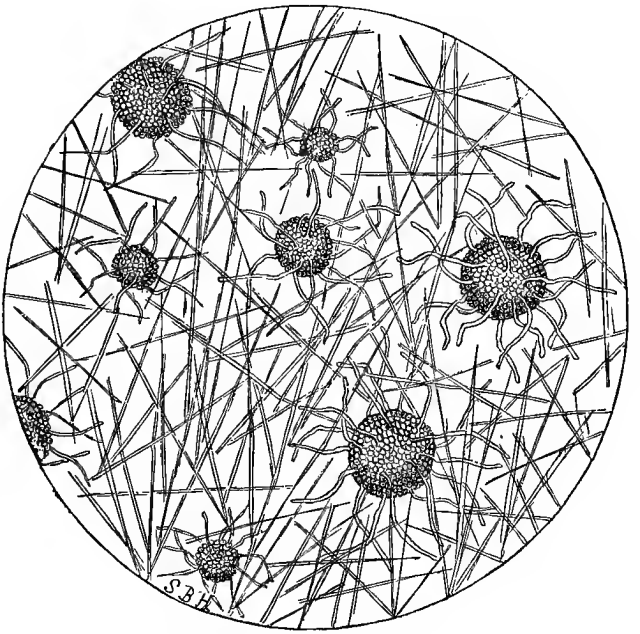
The grape, both fruit and vine, is covered with one of the web-like moulds, which has caused in some years the failure of the entire crop in the south of France and Italy, causing great distress among the vintage growers. M. Pasteur first discovered this fungus, and by his suggestions much has been done to restore the vineyards to a healthy condition.

The ferment-mould inhabits liquids—wines, ciders, vinegars, and the like. The story is told of a man who placed his cask of wine in a cellar to age. Some time afterwards, when he attempted to open the cellar-door, it was blocked by great growths of fungus. The cellar was literally filled with the fungus, which had revelled in the wine leaking from the cask. The empty cask was lifted on top of the fungoid growth to the ceiling.

This is the famous fungus found in the London docks, swinging and waving like gigantic cobwebs.

Of the fifth class the fungus that forms over our preserves and jellies is an example.

To the sixth class belong the very lowest plants. Among them are bacilli and bacteria, rod-like bodies, which increase by subdivision, and cause our most fatal diseases—cholera, yellow and typhoid fevers, consumption, diphtheria, cancer, the festering and gangrene of



GRAPE-FUNGUS

wounds, as well as the most destructive diseases of domestic animals, hogs, sheep, cows, and chickens.

Many fungi prey upon other fungi. There are also species which attack caterpillars, and finally destroy them. The parasite extracts all the juices, and when the creature dies its body is but an empty shell. The house-fly may often be seen, especially in seasons when some epidemic of disease is prevailing, fastened to a window-pane, dead, surrounded by a white cobweby fungus. Under the microscope the spores may be seen escaping from minute plant growths. The silk-worm is attacked by a fungus which is often very destructive.

One-third of the flowerless plants belong to the fungus family. It has been thought that their growth was spontaneous, since they appear in substances through the exterior of which it would seem impossible for the minutest spore to penetrate, as in the centre of a cheese and inside of an egg, inside of a fruit, and even within the stomach and intestines of man. It has been proved by careful experiment that the spores do in every case precede the plant. They were in the cheese-curds before the cheese was pressed. The shell of an egg is not impervious to spores, and they exist in the saliva of the mouth, and around teeth which are suffered to decay. Dampness is favorable to their development. The boots left in the closet will be covered with mildew. Spots appear on the cellar-walls, or even on the timber with which we build our houses. Dry-rot may cause hard-wood to disintegrate and become black dust. The leprosy in houses, against which some of Moses's regula-

tions were directed, was probably a fungus growth, the same which is found in the East to-day, and for which there is no known remedy save the destruction of the house.

Many moulds luxuriate in poisonous liquids, as arsenics and opium. Antiseptics destroy them, and a knowledge of the antiseptic treatment of wounds, the careful disinfection of hands and tools, is now as much a part of good surgery as is the skilful use of the knife. Salt is an antiseptic, and should be plentifully used in manuring crops. Powdered sulphur on the leaves of plants kills the fungus spores. The combination of sulphur with the oxygen of the air makes sulphuric acid, a poison fatal to the spores.

As a destroyer of insects which are hurtful to crops, the fungus may become the farmer's useful ally. How to cultivate the spawn and make it into a transferable form, and then how to infect insects with the spawn, and introduce them into a field infested with the same insects, are problems which may be solved in the near future, since competent scientific men are working upon just such questions.

## XVII

## PLANT ADAPTABILITY AND UTILITY

Migration of Plants—Flexibility—Hardness—The Birch—High Altitude Plants—Cinchona—Palms—Cacti—The Mesquite

Man and animals can at will change their abode. If too cold or hot, too moist or dry in one country, they can flee to another. Plants cannot migrate unassisted, yet, through the agencies of man, animals, and storms, are often borne far from their native homes into warmer valleys, up colder heights, over seas into new continents, and are deposited at last amid strange soils and climates.

Can they survive these violent changes? Many, perhaps most, do perish. Others develop remarkable tenacity of life, take on new forms, are dwarfed by cold, made large and luxuriant by heat, learn, if they must, to creep upon the ground, or send up tall stems, develop unwonted hardiness, or become more frail. There is a sunflower (*Helianthus autumnale*) which outlasts all the others, holding its golden notched rays bravely stiff and bright till winter's icy touch is upon it. May not its ancestors have been forced to live in cold regions, where they developed a hardiness really foreign to the genus?

A cowslip and primrose were once alike. Planted in wet and tall grass, the one had to stretch its stem in order to reach the sunlight, and became a plant bearing blossoms on a tall and slender scape. The other in shorter grass, in more exposed places, remained short and stocky.

It is because of such flexibility that our common vegetables—parsnips, carrots, turnips, potatoes—have been deduced from wild and even poisonous roots. So the fruits, apples, plums, cherries, strawberries, blackberries, etc., existed once only in their wild dwarfed state. The development of plant varieties and species is a fascinating occupation. It is impossible, however, to elaborate such a theme in a short paper, even if the results of Darwin's and others' researches were not within every one's reach. I have simply brought together a few facts to illustrate the flexibility of plant nature, and how in numerous instances this power of adaptation is of service to animals, so that arctic plants best serve the needs of arctic inhabitants, and tropical vegetation best suits hot, often dry, countries.

It is difficult to say in what the hardiness of plants consists. Why, when a purple and white aster grow side by side, does the white first succumb to the frost? "The one is taken, the other left." It cannot be density of tissue, for some of the most delicate flowers appear first in spring, while it is yet cold, and such are found in the region of perpetual snow. Travellers on Alpine summits marvel at the apparently fragile beauty of these snow-line plants. Such a flower is the *Gentiana nivalis*,

one inch tall, blooming, a companion of mosses and lichens, where sturdy trees cannot venture.

The trees whose wood is heaviest inhabit warm zones. The tree found farthest north is the birch. Snow falls through without breaking the light foliage, and its impervious bark, a non-conductor of heat, protects it from the cold. A stunted fir and pine reach latitude 72°, and next come the aspen and mountain-ash. The birch is an invaluable tree in the inhospitable country of Asiatic Siberia. Out of its bark shoes are made—some 25,000,000 pairs a year. The bark also furnishes boxes and jars for holding liquids, which the peasants stamp with curious patterns. It is used in tanning Russia-leather. The wood makes furniture and carriages. It is flexible and tough. The peasants draw the sweet sap in early spring and make a fermented liquor. A less questionable use, perhaps, and one not confined to Russia, is the use of birch twigs as a means of youthful discipline. In spite of all advanced methods, the birch-rod is still the emblem of authority in rural district schools—a supposed invaluable aid to early intellectual progress.

The presence of animals always indicates some form of plant life. The arctic dog and reindeer could not live without the moss, which constitutes their food or bedding. The arctic glutton is a singular and repulsive animal. It subsists upon swift-footed creatures, like rabbits and deer, and being itself slow-footed, could not catch its prey were it not for trees. Creeping with slow and silent tread out upon a branch, it remains

quiet and concealed till it can drop upon some unwary animal passing underneath. Then it thrusts its claws into the neck, and sucks the blood till the poor victim falls in a death-swoon.

The midnight sun of Norway makes it possible to raise turnips and potatoes as high as latitude 70°. Parsnips, carrots, cabbages, and barley find their limit at 66°. The grasses necessary for cattle do not grow above 60°. The fox-grass (*Alopecurus alpinus*) is the most hardy and northern.

Our old geography pictures of fur-enwrapped Laplanders, apparently always riding on sledges drawn by reindeer, make us think of theirs as a flowerless country. On the contrary, their short summer is full of bloom. The beautiful white and the yellow water-lilies grow upon their ponds. Saxifrages and other spring flowers are abundant, and many edible berries have time to ripen.

Our blue hepatica grows along the Gulf of Bothnia, with anemones. Birches and dwarf willows are the principal trees.

The heather is a cosey little plant, a native of cold countries. It covers large sandy flats of northern Germany, in which whortleberries grow. Reddening whole acres with its tiny pink blossoms, covering bare plains and bleak moors, the modest heather always seems to me to stand for that quiet, unostentatious virtue of which we say: "It hath done what it could."

The cranberry is a plant of cold bogs, although smaller the farther north it grows.

The ash, oak, and beech grow on the European Atlantic coast as far north as 63°. On our own colder seaboard all such trees reach their northern limit at lower latitudes.

European visitors notice the furze, or gorse, or whin, as it is variously called. It is an evergreen shrub with hairy stem, bristling all over with spines, which mostly take the place of leaves. The papilionaceous blossom is a bright saffron-yellow. The pods often burst with a crackling sound. Some species flower twice: in early spring and late autumn. A procumbent species, found on the Continent, especially in Denmark (*Ulex nanus*), has smaller blossoms and smoother stems. The furze has a habit of springing up in hedges, and from its spiny, impenetrable character adds much to the strength of any fence. Strangely enough, this thorny plant is serviceable as fodder for sheep and cattle. Sheep crop the young tender branches from below, and find shelter under the clustered bushes from storms and cold. Cows eating it give rich, untainted milk. The farmers used to bruise and pound the spines with a heavy mallet, but now there are machines especially constructed to prepare, by cutting into small pieces, the branches gathered fresh every day. Drought does not discourage this hardy, serviceable bush; it seems to welcome poor soil and cold weather.

Wherever man goes certain plants follow. One such sociable plant is the common mustard, the shepherd's-purse. Still another is the stinging-nettle. Up on high mountains, around the peasants' cottages, these

humble plants grow, seemingly self-transplanted. On the sides of the colossal Kunchain-Junga (that highest of the world's peaks) several villages are scattered. Half-way up, attendant upon these villages, barley, millet, strawberries, and currants grow. Upon Mount Dunkia, in Thibet, at a height of 23,400 feet, the arenaria and small Woodsia ferns have been gathered. This is probably the greatest altitude which a flower can attain.

A saxifrage has been found on the top of Mount Chimborazo, 15,770 feet high, beyond the limit of perpetual snow. The Alpine rose (*Rhododendron nivale*) is found in the herbariums of Swiss tourists. With the edelweiss, it prefers steep mountain-sides to valleys. There are rhododendrons of all sizes—from one trailing in melting snow to the *R. argentum*, 40 feet high, with great silvery leaves—found among the Himalayas at the oak and chestnut belt.

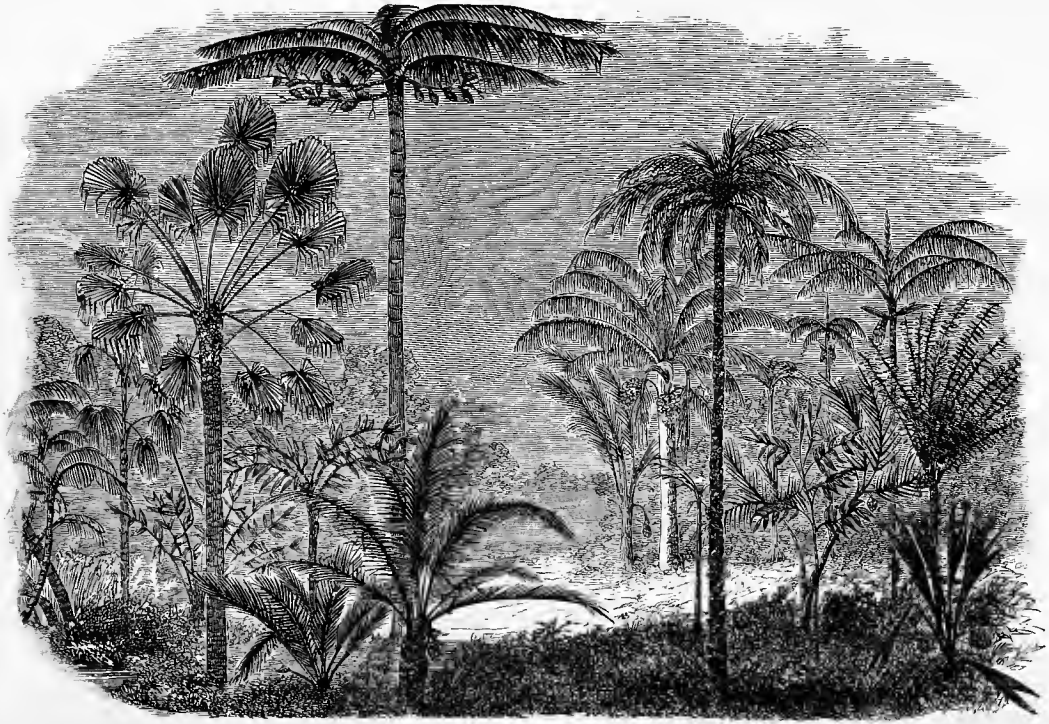
On this giant range of Asia's Himalayas grass and shepherd's-purse do not grow higher than 12,200 feet. At 22,000 feet mosses disappear.

As a rule, the slowly-growing plants—those which take years to mature—are the hardy ones. The hasty, hot-blooded annual lies sprawling, black and dead, upon the ground after one brief season's life. There is something almost sublime in the patience and reserve of, for example, a horse-chestnut. In the fall it forms the next year's buds, wraps them in thick gummy coats, and rocks them to sleep all winter, waiting without outward sign of life for the soft warm breath of spring.

The Cinchona is a mountain-tree indigenous in the Andes of Peru, at altitudes of from five to six thousand feet. There are thirty-six species, from which the bark used as a fever specific is obtained. The former wasteful way of procuring the bark was to strip it clean off the trees, felling them in order to get at the upper branches. As early as 1838 efforts were made to transplant the Cinchona. It is now successfully grown in large plantations in India, Ceylon, South Burmah, and Mauritius. The twigs from one to two years old are cut, and the main tree is left undisturbed. The name Cinchona is that of the Countess of Chinchon, wife of the Governor of Peru, who was cured of a fever by the bark of this tree, as prescribed by a Jesuit priest.

On the plains about the Caspian Sea (the Tartarian steppes) milfoil and wormwood grow several feet high. Thistles overtop and shade the low houses of the peasants. In fall the down of the thistle-blooms is blown off, and, collecting in white fluffy masses, is whirled by the wind across the steppes in big balls. They are regarded with superstition by the peasants, who call them "wind witches." The verse in Psalms lxxxiii. 13, may refer to this not uncommon Oriental sight: "O my God, make them like a wheel; as the stubble before the wind."

Two families of plants are especially adapted to peculiar conditions of climate and soil—palms and cacti. Palms are the oak, chestnut, and hickory of tropical countries. They supply not only fuel and lumber, but clothing, fibre, paper, starch, sugar, oil, wax, wine, and food. In some species dense thickets of canes grow



PALMS ON THE MIDOLE AMAZON

from an underground stem, or the stem, too weak to support itself, climbs by means of stout hooked prickles up tall trees, till it can raise its own foliage into the sunlight. The fibrous material which covers many trunks of palms makes strong cordage. It is the thread-like tissue of the leaf-stalks after the softer parts have decayed. Palms which have to withstand severe shocks of wind often send out roots from their trunks which serve for a firmer support. The blossoms, hanging in graceful sprays amid the long pendant leaves, are very beautiful. They are monœcious, both kinds in one tree, and the staminate and pistillate are often produced in different years. Wind and insects are the agents of fertilization. At times, in a high wind, a palm-tree is almost hidden in a mist of pollen.

The tallest palms are the cabbage (*Areca oleracea*) and wax (*Ceroxylon*), from 160 to 200 feet high. The leaves of the beautiful Jagua palm are 16 or 17 feet in length, and curl under at the tips, like plumes.

The cyathea, or tree-fern, resembles a palm. It grows in dark forests in the West Indies. It shuns the sun's rays, and thrives on foul air, near stagnant water. It seems like a relic of the long-buried coal-fields, resurrected, dazzled and blinded by the glare of our modern epochs.

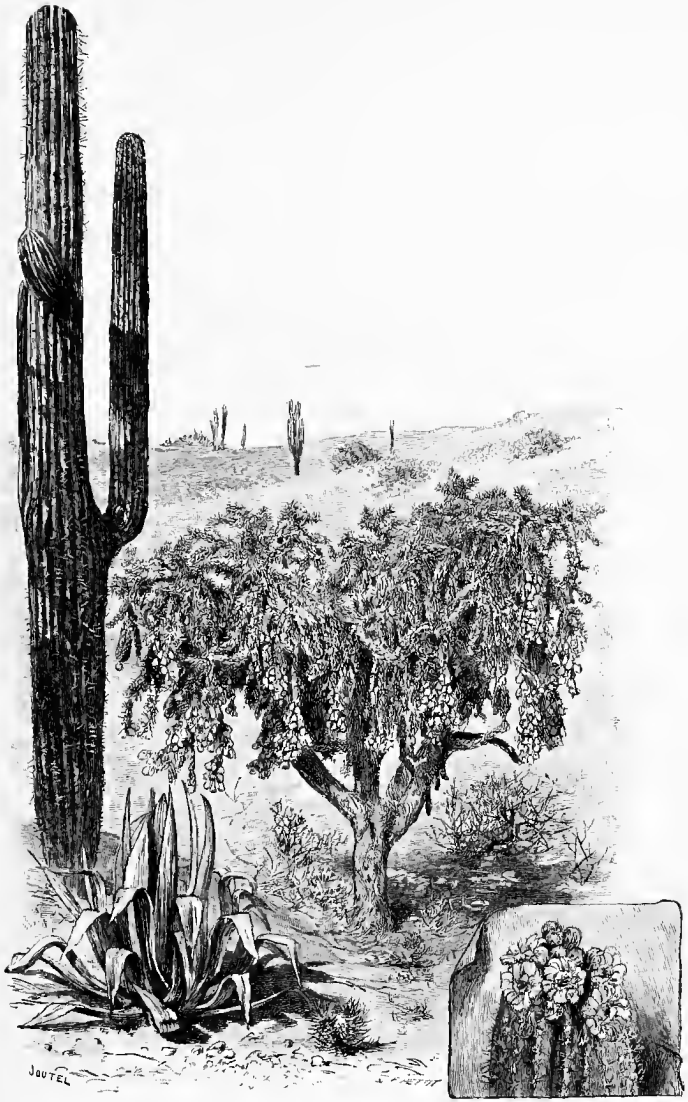
The Florida moss belongs to the order *Bromeliaceæ*. The moss, when steeped or buried till the outside rots off, becomes a dark, coarse fibre, like horse-hair, and is used for stuffing cushions. To the same order belong the Tillandsias, whose airy blossoms are among the

most beautiful sights of our Carolina forests. The channels of their leaves hold considerable water.

The yucca is a familiar sight upon our prairies. The spike of creamy blossoms grows from the heart of the ravelled leaves, six feet tall. Such a spike may bear 300 blossoms. The Mexican half-breeds make a soap from its bruised roots called "aniole." Though preferring sandy soil, this plant bears transplanting very well, and thrives in our eastern gardens.

The cacti are among plants what the camel is among animals—the plants of the desert. With their strong leathery skins provided with few stomata for evaporation, and their fleshy, succulent leaves, they live almost without moisture in the arid regions of Central America, Mexico, and Texas. They grow upon lava, almost upon bare rocks, in great heat, where no other vegetation can exist. Goats live on them. Cattle rip them open with their horns, or kick them with their hoofs, laming themselves in their attempts to get at the cool watery substance within. The fruits of many are edible, and make delicious cooling drinks. The stems are round or square, fluted or ribbed, provided at short intervals with clusters of fine or coarse prickles, from the centre of which new buds start. The Visnago provides the Mexicans with toothpicks, fifty thousand being taken from one plant, which may weigh a ton.

Our only Eastern species is the Opuntia, or prickly-pear cactus, whose bright yellow blossoms are familiar to all who have climbed the highlands of New York or New Jersey. The fruit is a juicy, pleasant-tasting (when




CACTI

ripe) pear-shaped body, with a scar at the top, from which the calyx has fallen. In Southern Europe this fruit is much esteemed, and is sold upon the street-stands. One of this genus furnishes food for the cochineal insect. In New Mexico its cultivation forms one of the people's industries. Fifty thousand plants are grown and tended in a single plantation, three crops of the insect being gathered in the course of a year.

The melon-cactus is an oval body, one or two feet high, producing on the summit rosy-colored blossoms, which form red berries. These plants spring from rock crevices, and look very singular.

One, the giant-cactus (*Cereus giganteus*), attains great height. It is a native of the most desolate regions of New Mexico, and grows among rocks, where there seems to be absolutely no soil. It sends a straight, often branchless stem, fifty or sixty feet high. If there are branches they grow at right angles to the stem, then bend abruptly upward and grow parallel with the stem. The flowers, three or four inches across, are of a rich cream color, and spring from yellow cushions near the summit, furnished with large and small thorns. When the fruit is ripe the outside bursts, and the pieces roll back like flower-petals. Inside are small black seeds embedded in a reddish pulp, which the Pinos and Papagos Indians gather and make into a rich preserve. The fruit is gathered by a forked stick fastened to a long pole. This is a sombre plant of slow growth, living several hundred years. It forms a striking feature of a landscape where desolation reigns supreme—a trec-

less, grassless, flowerless region. Stretching their gaunt arms upward, lonely, erect, like telegraph-poles, not even swaying in the wind, these weird plants are yet wonderful illustrations of plant adaptability and the generous bounty of what we call nature, which touches with green even the most outcast places.

The creeping cereus flowers at night only. It has a bright orange calyx, and delicate white petals, fourteen inches across. It is a native of Honduras.

Among the plants most flexible to changing conditions of soil and climate is the mesquite of Texas (*Prosopis glandulosa*). It is a low wind-beaten shrub, with delicate feathery leaves, so beautiful that if it were rare it would stand side by side with gorgeous palms and rare tree-ferns in our botanical gardens. Like many another good thing, it has made itself too cheap. So, in Texas, the ranchmen grub it out of their fields with maledictions on its enormous and tenacious roots, so disproportioned to its growth above ground. These roots, however, together with the tenuity of its leaves, enable it to hold its own against the rudest storms, those awful "northers" of Texas. The wind passes through the shrub, bends it with wild caresses, but cannot break the sturdy, yielding thing. The mesquite protects the scant grass from the burning sun, and protects itself from too hungry cattle by its bristling thorns, while, in partnership with the grasses, it takes care of the cattle. And here is where the wonderful story begins. (I quote from the note-book

of a friend who has kindly lent it to me for this purpose.)

"In years of drought—not uncommon in Texas—when the grasses are burned to deadness, and the cattle

CACTUS

might starve, the little mesquite bushes hold out a bounteous crop of a sort of bean, very rich in nutriment, ample to carry the cattle through an otherwise bad time; and the curious part is that the mesquite never produces those beans at any other time. As if with a housewifely eye that nothing be wasted, nature

has placed the mesquite blossoms on such delicate stems that when there are spring rains the blossoms are beaten off, and the tree stores up its strength to produce a double crop when the dry season comes around again. It is ready for the bees, too, in time of drought, spreading a feast for them, which serves as well as the flowers which might have been, producing a gum that is everything desirable as a factor for honey; while in the years when the prairie flowers are plenty, the frugal mesquite keeps its stock of sweetness well stored out of sight."

The note-book adds that San Antonio is paved with blocks made from mesquite roots, and that these block-pavements are hard and durable, while "the fire that comes out of those old gnarled and earth-stained roots, laid in one of those wide open fireplaces of the South, is enough to make one a Parsee."

## XVIII

## SEEDS AND FRUITS

Ovules—Usurpations of Ovules—Dissemination of Seeds by Wind, Water, and Animals—Different Fruits in Botanical Language—The True Lover of Flowers

The ovule is that part of a flower which when fertilized becomes a seed. It is a projection of the inner wall of the ovary, and assumes various positions, attached to the bottom, top, or side of the cavity. One or several may fill the cell. Considering the pistil as a folded leaf, the ovules, and of course the seeds, are generally formed upon the enlarged margins of the leaf, called placentæ. Pods and capsules, if cut across, and viewed through the microscope, show the placentæ with their seeds attached. To determine whether several leaves have united to produce a compound pistil, or whether a single ovary-cell may be divided by false partitions, is not always easy. Usually, as has been said, the ovules are borne upon the leaf margins which project into the ovary cell. But sometimes, as in the common water-lily, the whole interior surface is covered with seeds.

In some of our common nuts, singular usurpations among the ovules occur. For example, the acorn, a

single fruit, was originally a three-celled ovary with two ovules in each cell. One ovule only matures and becomes an acorn, while two cells and five ovules are overmastered and absorbed by the one successful nut. If all the ovules of a chestnut matured, there would be twelve or fourteen in place of one. The birch, elm, horse-chestnut, and buckeye present like examples of usurpation. Often, indeed, the nut expanding obliterates even cell divisions.

Many devices are sought by the matured fruits to secure wide dissemination. The wind is the chief carrier of light seeds, and seeds of maple, ash, and birch are furnished with wings by which they are easily lifted and floated upon air currents. These veiny, gossamer-like growths are terminal, or they surround the seed. They are beautiful illustrations of the ingenuity by which plants often accomplish their objects. We all know the twin maple seeds, winged from the apex, which litter our sidewalks in spring. Such a fruit is called a samara.

SAMARA

Another method of dissemination is by the clinging of seeds to the coats of animals. Such seeds are rough, or have hooks, or burs, or long hairs. My earliest connection with a "sewing society" was secured by walking purposely through clusters of "stick-tights," as the little girls called the bur-like fruits of desmodiums, and by picking them off my dress

and apron afterwards, seated demurely upon the mossy trunk of a fallen tree. Little did we children dream that in our play we were fulfilling destiny. We were animals acting as disseminators.

It is by means of bristles, or fine hairs, or scales, that the seeds of some compositæ are carried so far, and members of the family made so ubiquitous.

The fine down at the end of a milk-weed or epilobium seed is a coma. It is this part of the cotton-seed which gives this plant its commercial value. The bur-marigold has barbed, arrow-like lances, which adhere to anything rough. Bur-grass, a common water-plant, has stout savage spines. Martynia is a plant of South America, whose seed-vessels have large horny hooks, which attach them to the tails of cattle roaming through the pampas.

Water is a fruit-carrying agent. In fact, in that geological era when the earth was covered with lakes, marshes and bogs, it was the sole medium. In the drift material which collects along the shores of our ponds, countless germinating seeds may be found. The cocoa-nut palms appear in islands hundreds of miles apart, because the tiny, boat-like cocoanut shells, with kernels enclosed, voyage safely over the ocean waves, and are tossed up at last on distant shores.

There are other small seeds which have a way of their own. They are coated with short hairs, which, when moistened, burst and throw out long thread-like, mucilaginous spirals. These extend in every direction,

and when it rains fix the seed to the soil. Such seeds are those of salvias and senecios.

In botanical language, fruit and seed are not quite synonymous. The entire pistil, or several pistils, may go to form fruit. Other parts of the flower—the receptacle, calyx, and even the bracts—may enter into an edible fruit. In hawthorn, apple, quince, pear, both calyx and receptacle adhere to the pistil, and become juicy and fleshy. Such fruits are pomes. The core of an apple is its ripened pistil.

In a strawberry we have an enlarged and fleshy receptacle, with the akenes—dry, small seeds, scattered upon its surface. Turn the strawberry inside out, and you have a rose-hip. Petals and stamens are borne upon its mouth, pistils and fruits along its inner surface.

Cherries, plums, and peaches are stone-fruits or drupes. In these the outer coat of the seed-vessel becomes succulent, the inner hardens into a stone. An almond is like a cherry, except that the outer coat remains dry and juiceless. The huckleberry is not a true berry, but a tomato is! The edible part of the huckleberry is the calyx grown fleshy, whose five points may be seen above. The true seeds are enclosed in hard coats, and are in fact drupes, scattered regularly within the succulent calyx. Grapes, cranberries, gooseberries, currants, and even bananas, are true berries. For a berry is a fleshy or juicy seed-vessel. Oranges and lemons are berries with leathery rinds. Melons, squashes, cucumbers, and gourds have hard rinds, and are classified as pepo or gourd fruits. In these the

edible, fleshy part is either the calyx transformed, or, in the watermelon, the placentæ grown pulpy and juicy.

A nut is a hard, one-celled, one-seeded fruit. The acorn-saucer, chestnut-bur, and the leafy covering of a hazel-nut are a sort of involucre, termed a cupule. Walnuts are something between stone-fruits and nuts.

Grains of wheat and kernels of corn are fruits whose seed completely fills the seed-cell, surrounded by a very thin covering.

The fruit of buttercups and anemones are akenes, the latter feathery-tailed.

FEATHERY-TAILED AKENE OF ANEMONE

All these fruits are simple, that is, produced from a single pistil. When several pistils are clustered together, we have aggregate fruits like the blackberry and raspberry. In the former the separate fruits grow on a fleshy receptacle; in the latter the receptacle is dry and separate from the clustered fruits.

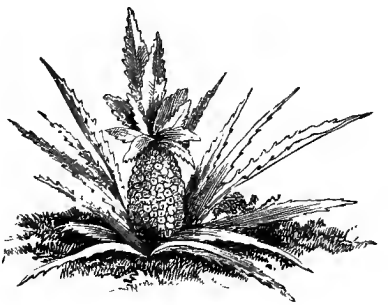
The wintergreen-berry is made of a calyx grown fleshy, entirely surrounding the five-celled fruit, in imitation of a red berry. The top of the calyx is easily seen two-thirds of the way up the berry.

Partridge-berry and the fruit of twin-honeysuckle are the union of two blossoms into one fruit. Several thus joined together, the product of many flowers, make the mulberry. The blackberry and mulberry are therefore very different in structure, the one (mulberry) being

the union of many flowers, the other (blackberry) the union of many pistils in one flower.

A pineapple utilizes and blends into one juicy mass around the stem-axis many flowers with their bracts and all their parts.

A fig is an inverted mulberry, that is, it is a multitude of flowers concealed in a hollow flower-stalk,



PINE-APPLE

which becomes pulpy and edible. The fruit of a fig seems to have been preceded by no blossom.

Pine-cones are multiple fruits. Hops are like them, except that the scales are thin and flexible, like bracts.

When fruits are dry, and crack open themselves, they are pods. A follicle is a pod opening on one side only. Larkspur, columbine, milk-weed, and marsh-marigold are examples. The pea-pod is a legume, and the name Leguminosæ is applied to the pea family.

Sometimes the pod is scalloped along the edges and joined between the seeds, like desmodiums.

The two or more pistils of St. Johnswort coalesce into a capsule which splits down at maturity into as many pieces as there are carpels.

Portulaca and purslane hold their seeds in little cups from which the top may be removed like a lid. This kind of pod is a pyxis.

The fruit of mustard is a silique in which a partition runs lengthwise through the middle of the pod, bearing seeds upon both sides.

It is not necessary for our enjoyment of a Newtown pippin that we call it a pome, nor does a rose smell sweeter because we know something of its botanical structure. We may gather a nosegay of spring flowers and take pleasure in its evanescent beauty without knowing to what family the claytonia and hepatica belong.

Nevertheless, the truer lover of flowers must be the botanist, rather than the ignorant girl who pulls daisies to wear at her belt—to whom any flower is a posy, to be plucked and thrown away, instead of one of the most wonderful of the works of God, illustrating, from seed to fruit, divine thought and plan, as much as do the starry suns in their everlasting orbits.

The mutual dependence upon each other of plants and animals is a potent reason for studying the sister kingdom. Neither man nor plant could live in a desert. By the most subtle, marvellous devices, by living each

upon the other's refuse, an accumulation of conditions which would be finally fatal to each is prevented.

The object of the foregoing chapters has been, not a scientific treatise on Botany, but to show how comparatively simple and easy it is, and what a pleasure it is, to know something — a great deal—about plants. As stated in the introductory chapter, it is as a recreation, a summer amusement, that the pursuit of botany is earnestly recommended.

When Agassiz was fifty years old, the anniversary was celebrated by our poet Longfellow in beautiful lines. His conception is that in the very early life of the great naturalist—

"Nature, the old nurse, took
The child upon her knee,
Saying, 'Here is a story-book
Thy Father hath written for thee.

"'Come, wander with me,' she said,
'Into regions yet untrod;
And read what is still unread
In the manuscript of God.'

"And he wandered away and away
With Nature, the dear old nurse,
Who sang to him night and day
The rhymes of the universe.

"And when the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvellous tale."

We, too, may wander away with "Nature, the dear old nurse." The "story-book" is not sealed from any persevering, reverent student. Whether we regard plants as commissioned to fill the earth with beauty and gladness, whether to meet the wants of insects, or the food of animals, they certainly testify of the Creator's love and infinite wisdom. One and all, the largest and the smallest of them reveal His perfect thoughts.

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